



3.4 RIPARIAN HABITATS

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3.4.1 Introduction

Riparian habitats include instream habitat and stream channels, adjacent floodplains and wetlands (which often include seeps and springs) (see Section 3.5). A wide variety of hydrologic, geomorphic, and biotic processes determine the character of riparian areas. Raedeke (1988) describes riparian systems as having long, linear shapes with high edge-to-area ratios and microclimates distinct from those of adjacent upland areas. Portions of riparian areas are disturbed from periodic inundation and water is present at or near the soil surface during all or part of the year. These unique characteristics result in variable soil moisture conditions and distinct plant communities that are often more diverse than surrounding upland areas.

Riparian areas have distinctive resource values and characteristics that make them important zones of interaction between terrestrial and aquatic ecosystems. These areas are especially dynamic segments of a watershed. Disturbances in upland areas (e.g., fire and windthrow), as well as disturbance processes unique to stream systems (e.g., channel erosion, peak flows, floods), affect riparian areas. Highly functional riparian areas are generally composed of large conifers or a mixture of large conifers and hardwoods. Riparian vegetation is important for maintaining stream bank and floodplain integrity. The vegetation slows water velocity on the floodplain and plant roots inhibit erosion along



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stream banks, reducing sediment deposition in streams (Section 3.2). Riparian vegetation also helps to provide shade, leaf, and needle litter important to aquatic food chains, and LWD which is an important component of instream fish habitat (Section 3.7). Riparian ecosystems are also important for a variety of plant and non-aquatic animals. Riparian areas provide important reproductive and foraging areas and/or dispersal/movement corridors for a wide variety of wildlife (Section 3.8).

Clearing or harvesting trees near stream banks and associated road construction can affect riparian ecosystem functions. Figure 3.1-1 displays the relationships among management activities and the environmental components of the aquatic ecosystem. This figure demonstrates the critical central role that riparian functions play in the aquatic ecosystem.

The Affected Environment Section (Section 3.4.2) will summarize the primary functions of the riparian area. In addition, the Affected Environment Section will provide a general understanding of the history of riparian management/riparian protection on private and state lands in Washington and the current riparian conditions in Washington state. In the Environmental Effects section (Section 3.4.3), each alternative will be evaluated focusing primarily on the different riparian management strategies. Section 3.4.3.1 identifies the riparian function criteria used to evaluate the alternatives. Section 3.4.3.2 evaluates how well the different riparian management strategies protect the primary functions of the riparian area using the criteria. This evaluation is also supported by a literature review and summarization of criteria development described in Appendix B and riparian analyses described in Appendix D.

3.4.2 Affected Environment

3.4.2.1 Riparian Functions

To understand the effects of various management actions, it is important to understand the function of riparian areas, which have been reviewed by many authors (e.g., Karr and Schlosser, 1977; Meehan et al., 1977; Raedeke, 1988; Bilby, 1988; Murphy and Meehan, 1991; Beschta, 1991; Castelle et al., 1991a). The most important recognized functions of stream riparian areas include LWD recruitment, leaf and needle litter production, stream shade, microclimate, stream bank stability, and sediment control. Stream bank stability and sediment control are introduced and evaluated in Section 3.2 (sediment). The other riparian functions (LWD recruitment, leaf and needle litter production, stream shade and microclimate) are briefly summarized below.

LWD Recruitment

Riparian areas are an important source of LWD that enters, or is recruited to, the stream channel. LWD includes entire trees, rootwads, and larger branches. Numerous studies have shown that LWD is an important component of fish habitat (Swanson et al., 1976; Bisson et al., 1987; and Naiman et al., 1992). Trees that fall into streams are critical for sediment retention (Keller and Swanson, 1979; Sedell et al., 1988), gradient modification (Bilby, 1979), structural diversity (Ralph et al., 1994), nutrient production (Cummins, 1974), and protective cover from predators. LWD also creates storage sites for sediment in all sizes of streams. In small headwater streams, wood controls sediment movement



downstream minimizing the risk of debris flows. In larger streams accumulation of coarse sediment behind LWD often provides spawning gravels. LWD plays an important role in stream nutrient dynamics by retaining leaf litter and needles.

Large wood recruitment originates from a variety of processes including tree mortality (toppling), windthrow, undercutting of stream banks, debris avalanches, deep-seated mass soil movements, and redistribution from upstream (Swanson and Lienkamper, 1978). First and second-order headwater streams can also provide wood to larger higher order channels downstream (Potts and Anderson, 1990; Prichard et al., 1998; Coho and Burges, 1991). Two predominant mechanisms have been observed for the movement of LWD between stream types: transport during high flow events and debris torrents, which includes dam-break floods and debris flows (Swanson and Lienkaemper, 1978). However, the former mechanism is more common in third- to fifth-order streams because much of the wood that falls into streams is too large to float in smaller streams (Swanson and Lienkaemper, 1978). The occurrence of debris torrents, although less frequent than the redistribution of LWD from high flows, can introduce large amounts of LWD (Lamberti et al. 1991). Additionally, debris flows originating in managed forests (albeit, under older less protective rules) occurred at a rate much higher than that of unmanaged forests (Swanson, 1976; Morrison, 1975). The majority of debris flows and dam-break floods are initiated in lower order streams, primarily second-order streams (Coho and Burges 1991). These may travel upwards of 2.5 miles into higher order low gradient valley floors, and cause significant damage to riparian vegetation and aquatic habitat during and after the event (Coho and Burges 1991). “The most obvious schemes for avoiding the destructive forces of organic debris movement are maintaining contiguous riparian zones of mature conifers around low order channel and minimizing deposition of logging slash and debris into those channels” (Coho and Burges 1991).

The potential size distribution of LWD is also an important factor when considering the appropriate activities in buffer strips relative to LWD recruitment. There is a strong relationship between channel width, and the size of LWD that forms a pool (Bilby and Ward, 1989; Bilby and Wasserman, 1989; Beechie and Sibley, 1997; Beechie, 1998), where smaller pieces of LWD function in smaller streams. LWD that is large enough to form a pool is referred to as “functional LWD.” In contrast, “Key piece LWD,” is a subset of “functional LWD,” and considered by some to be a better measure of the important wood recruitment sizes. Key pieces have pool-forming capacity similar to “functional wood size,” but also are effective in trapping other smaller more mobile pieces of LWD (i.e., forming logjams), and are more likely to have long-term stability.

Minimum functional LWD size increases with channel width (Bilby and Ward, 1989; Bilby and Wasserman, 1989; Beechie and Sibley, 1997; Beechie, 1998; Washington Forest Practices Board, 1995). For example, mean functioning LWD diameter increased from 11.7 inches in west side channels 5 feet wide to 21.7 inches in channels 44 feet wide (Bilby and Ward, 1989). Key piece size is also related to stream size and is about 15 percent larger in diameter than functional piece size for a 40 foot wide stream (Washington Forest Practices Board, 1995; Bilby and Ward, 1989). As a result, RMZs need to ensure not only an appropriate amount or volume of wood, but wood of sufficient size to serve as both



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functional pieces and key pieces (Murphy, 1995). Consequently, the length of time needed for riparian areas to produce LWD after harvest depends upon the size of the stream, tree growing conditions in the riparian area, and the tree type. Measurable contributions of wood from second-growth riparian areas are documented to take anywhere from 60 to 250 or more years depending on region and size of stream (Grette, 1985; Bilby and Wasserman, 1989; Murphy and Koski, 1989). Therefore, larger streams that are deficient in LWD and have early seral stage riparian stands are likely to remain deficient in LWD for a longer period of time than smaller streams (MacDonald et al., 1991).

Leaf and Needle Litter Production

In aquatic systems, vegetative organic materials originate within the stream, such as algae production or from sources outside the stream, such as leaf and needle litter. Stream benthic communities (e.g., aquatic insects) are highly dependent on algal production detrital (i.e., organic debris) inputs. The abundance and diversity of aquatic species can vary significantly depending upon the total and relative amounts of algae and leaf and litter inputs to a stream (IMST, 1999). For example, grazing insects are more commonly found in stream reaches with algae production, while shredding insects are more commonly found in areas rich in leaf and needle input (IMST, 1999). Detrital input from outside of the stream is the primary source of detrital input into small and medium size streams through the annual contribution of large amounts of leaves, cones, wood, and dissolved organic matter (Gregory et al., 1991; Richardson, 1992). In contrast, wide high order streams with higher levels of direct sunlight, or low order streams with an open riparian canopy have more algal production. As a riparian stand ages, the amount of litter-fall increases (IMST, 1999). The importance of this type of detrital input varies among streams, but can provide up to 60 percent of the total energy input into stream communities (Richardson, 1992). Litter deposited into small steep-gradient streams in forested areas high in a watershed is generally transported downstream because higher gradient streams are less likely to retain deposited organic material until it has decomposed. Therefore, small (low-order) streams are important sources of nutrients and contribute substantially to the productivity of larger streams in the lower reaches of a watershed (IMST, 1999).

Stream Shade

There are several factors that make up the heat balance of water (see Section 3.6 and Appendix B) including: air temperature, solar radiation, evaporation, convection, conduction, and advection (Brown, 1983, Adams and Sullivan 1989). Stream temperatures have a natural tendency to warm from a streams headwaters to the ocean (Sullivan et al., 1990; Zwieniecki and Newton, 1999). However, seasonal and daily cycles produce a high degree of variability in stream temperature. For example, water temperatures increase during daytime and decrease at night. Other site-specific factors such as latitude, regional weather (e.g. proximity to the ocean), stream size, groundwater inflow, and distance from watershed divides all can affect stream temperature changes (Beschta et al., 1987; Sullivan et al., 1990). During the summer, when stream temperatures are the highest, the combination of warmer air temperatures, increased direct solar radiation and a decreased stream flows are the major factors affect stream temperature (Beschta et al., 1987). Of these three factors, forest management can have the greatest effect on direct



solar radiation by reducing shade. Shade cannot physically cool the stream down, but it can prevent further heating of the stream and therefore maintain the cool water temperature from groundwater inputs or tributaries (OFPACSW, 2000). Shade provided by riparian vegetation has been shown to be successful in minimizing or eliminating increases in stream temperature associated with timber harvest (Brazier and Brown, 1973; Lynch et al., 1985). Other factors that affect shading include stream size, orientation, local topography, tree species, stand age, and stand density.

Microclimate

Microclimate is a collection of variables that are highly dependent on local conditions; hence, microclimates tend to vary greatly across the landscape. Important components of microclimate include solar radiation, soil temperature, soil moisture, air temperature, wind velocity, and air moisture or humidity (Chen, 1991; Chen et al., 1992; Cadenasso et al., 1997). Changes in microclimatic conditions within the riparian zone resulting from removal of adjacent vegetation can influence a variety of ecological processes that may affect the long-term integrity of riparian ecosystems (Spence et al., 1996). For example, many of the variables considered in microclimate studies (air temperature, humidity, wind velocity) are also variables that affect water temperature (Sullivan et al., 1990); an important component to fish habitat. Additionally, microclimate is known to be important for stream/riparian species other than fish, such as amphibians (see Section 3.8). In general, due to their low-lying position on the landscape, riparian areas tend to be cooler than the surrounding hillslopes, especially during the night. Because riparian areas are adjacent to water bodies, they often have a higher relative humidity under the canopy than similar upslope areas. This increase in humidity combined with shading effects can cause intact forested riparian areas to have a moderating effect on microclimate (Beschta, 1995).

3.4.2.2 Historic Protection of Riparian Areas

The protection of riparian areas is considered critical to the long-term health of aquatic ecosystems (FEMAT, 1993; Cederholm, 1994; Murphy, 1995). The protection of riparian areas is usually implemented by restricting management activities within an area adjacent to water bodies referred to as the riparian management zone (RMZ). Management within RMZs (also known as stream buffers) usually involves two main features: (1) establishment of a protective buffer width, and (2) restrictions on allowable activities (e.g., timber harvest prescriptions) within the buffer. Within the scientific community, protection of riparian areas is considered central to salmonid conservation efforts (FEMAT, 1993; Cederholm, 1994; Murphy, 1995). Protection of water quality and fish habitat is often given the highest management priority, but buffers may also be designed to benefit wildlife and other non-fish aquatic species.

Forest practices are constantly being revised in light of new scientific information, political compromises, and changing public awareness and demands for forest and water resources. The Washington State Forest Practices Act of 1974 created a Forest Practices Board, which promulgates forest practices rules. The first rules only took into consideration changes in stream temperature and bank stability for the aquatic ecosystem. All riparian trees could be cut, sparing only the understory on certain temperature-sensitive streams. In 1987, new



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forest practices rules that derived from the Timber Fish and Wildlife (TFW) Agreement were implemented. The rules were again revised to further address environmental concerns, including temperature, in 1992.

Under Washington's current forest practices rules, RMZs are required on Type 1, 2, and 3 waters, but not on Type 4 and 5 waters unless warranted by site conditions. In western Washington, the minimum RMZ width is 25 feet. The maximum RMZ width depends on stream type and width, and ranges from 100 feet on Type 1 and 2 streams over 75 feet wide, to 25 feet on Type 3 streams that are less than 5 feet wide. For each stream type, buffer width can vary between the minimum and maximum values depending on the width needed for stream shade. Some timber harvest is allowed in the RMZ depending on stream type. Site-specific information from watershed analysis may result in prescriptions for larger buffers. Rules for eastern Washington are generally similar to those for western Washington. The RMZ width for Type 1, 2, and 3 streams is 30 to 50 feet on each side of the stream for areas of partial harvest, and must average 50 feet for areas to be clearcut.

3.4.2.3 Existing Condition of Riparian Areas

In Washington state, the condition of riparian habitats on private and state forest lands that have been harvested during the past 25 years has largely developed under forest management governed by some form of forest practices rules. The condition of riparian areas in harvest units that are greater than 25 years old, largely reflect a lack of riparian harvest restrictions. This condition is described in the following two subsections according to the riparian vegetation that is currently present and the extent of roads that have developed in these riparian lands.

Riparian Vegetation

The vegetative communities that are commonly associated with riparian areas can be divided into three general areas of Washington: forested areas in western Washington, forested areas in eastern Washington, and the non-forested shrub-steppe region in eastern Washington (Knutson and Naef, 1997). For the purpose of this document only forested riparian areas are generally described. The species, sizes, and density of vegetation occupying a riparian site are dependent upon soil moisture conditions and disturbance history.

Western Washington riparian habitats are associated with wet environmental conditions. Although considerable site-specific variability occurs, general vegetative characteristics include: the presence of a mixture of conifer and hardwood trees (hardwoods are more abundant where natural and human disturbance is frequent); the conifer tree species (e.g., western hemlock, western red-cedar, and sitka spruce) are tolerant of shade and periodically saturated soils; red alder is nearly always found in young and disturbed stands; upland conifers (e.g., Douglas-fir) and hardwoods (e.g., big-leaf maple) are dominant in small streams which have narrow riparian areas; lowland rivers and forested swamps with frequent flooding or gravelly soils often include black cottonwood, willow and red alder; swampy areas may also have vine maple, cascara, willow, western red cedar, Sitka spruce, and western hemlock (Knutson and Naef, 1997).



Eastern Washington riparian habitats can be divided into elevation zones. Forested riparian areas of eastern Washington typically located in deeply-incised ravines in mountainous terrain (Carlson et al., 1990 in Knutson and Naef, 1997). Lower elevations with moist soils and temperate microclimates support cedar, western hemlock, big-leaf maple, quaking aspen and other hardwood trees. Larger trees, snags and downed wood can be abundant in unmanaged areas. These relatively moist riparian areas also include a variety of understory shrubs and herbs including willow, red-osier dogwood, mountain alder, devil's club, and other species. Drier sites are characterized by ponderosa pine in the uplands while trees in riparian areas include Douglas-fir, paper birch, black cottonwood, and quaking aspen. High-elevation riparian sites often have saturated soils that are dominated by understory species rather than by tree species. Where trees exist, they are commonly subalpine fir or Engleman spruce and down wood is abundant because decomposition is slowed by cold temperatures. Shrubs and herbs at high elevation are relatively diverse, but generally stunted due to the more severe environmental conditions (Knutson and Naef, 1997).

Current riparian vegetation condition on private and state lands is mostly a function of past management practices, but natural phenomenon such as wildfire, blowdown, non-management related landslides, and disease have also contributed to conditions in many areas. Because riparian protection rules are a relatively recent phenomenon in Washington State (1982), the majority of riparian forests on state, private, and some federal lands have been logged at least once. Therefore, long-term changes to the riparian habitat character have resulted from multiple forest practices over time. These changes to riparian habitat structure include: simplification of the plant community, both in composition and structure (Knutson and Naef, 1997). Today it is believed that red alder currently dominates more riparian sites on the west side than was "typical" under natural disturbance regimes (McHenry et al., 1998).

Riparian habitat problems somewhat unique to eastern Washington forested areas are related to fire management and other riparian management factors not covered under this EIS, such as grazing, mining, and irrigation. Studies have shown that livestock grazing within riparian areas eliminates or reduces streamside vegetation, destabilizes stream banks, causes channel sedimentation and aggradation, widens channels, increases stream temperature extremes, lowers the water table reduces bank undercut, and reduces pool frequency and depth (Armour et al., 1991; Chaney et al., 1993; Kauffman and Drueger, 1984; Kovalchik and Elmore, 1992; Meehan, 1991; Platts, 1991). Grazing pressure usually is higher in the riparian zone because there typically is more shade, surface water for drinking, and more succulent vegetation (Platts, 1981). As a result, eastern Washington riparian areas include dense understories, dense reproduction and more fire-intolerant species resulting in higher fuel accumulation and more intense and destructive fires as compared to natural conditions (Wissmar et al., 1994) (see Section 3.9). The natural fire return interval for cedar, spruce, and hemlock stands of western Washington is about 937 years and about 217 years for Douglas-fir stands (Agee, 1993). The return interval (cycle or turnover time) is the mean time between disturbances on a given site. For the west side, fires were generally more intense and when they occurred were more often stand-



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replacement fires. In contrast to the west side, natural fire return intervals for drier east side pine forests (lodgepole pine, ponderosa pine, or mixed conifer) range from 15 to 110 years and were usually not stand-replacement fires (Agee, 1993). Fire management practices in all areas have increased these intervals during the last century (Agee 1993) and more intense stand-replacement fires have resulted with more recent fires. In addition, higher moisture levels can increase fire return intervals in riparian areas (Agee, 1993). Natural disturbance from fire on the east side is an important factor defining stand seral stage characteristics under unmanaged conditions. In contrast, wind storms have a larger effect on west side forests with return intervals of about 119 to 384 years for small-scale to large-scale storms (Harcombe, 1986 as cited in Agee, 1993).

As a basis for discussing current conditions, Table 3.4-1 presents the linear extent of streamside vegetation based on seral types that currently exist on riparian lands subject to Washington forest practices rules (based on a random sample of lands –see Appendix A). Seral stages, which are related to vegetation structure, are described in terms of early seral, mid-seral, or late-seral (see Appendix C for definitions) to reflect the species and/or condition of the vegetation and animal communities that are generally characteristic of different periods of succession. Seral stage provides a general picture of riparian condition and quality.

Unnaturally high levels of early seral stage are primarily a result of timber management activities and, to a lesser extent, fire, blowdown, and other natural processes that occur in riparian areas. This stage generally produces riparian vegetation that cannot provide a properly functioning riparian system important to aquatic and terrestrial biota. In contrast, later seral stages can fully provide for riparian functions (e.g., shade and LWD recruitment for aquatic biota [Section 3.7]) and more complex vegetative structure (e.g., downed logs and snags for terrestrial biota associated with riparian habitat [Section 3.8]).



Table 3.4-1. Estimated Percent of Each Seral Stage along Forested Streams on Private Lands ^{1/}

Water Type	Seral Stage - Percent by Water Type (%)		
	Early	Mid	Late
West Side-Private Lands			
Types 1-3	64%	33%	2%
Types 4-5	81%	18%	1%
All Streams	78%	21%	1%
East Side- Private Lands			
Types 1-3	60%	36%	4%
Types 4-5	61%	33%	6%
All Streams	61%	34%	5%

^{1/}Based on a random sample of private and state forest lands (see Appendix A). The sample includes the following stream miles: West side Type 1-3 = 76 miles; West side Type 4-5 = 202 miles; East side Type 1-3 = 21.6 miles; and East side Type 4-5 = 122.8 miles. Seral stage definitions are given in Appendix C.

Within the lands subject to forest practices rules, approximately 78 percent of the west side stream miles and 61 percent of east side stream miles flow through early seral stage riparian areas, while about 1 percent of the west side miles and 5 percent of the east side miles are late seral (see Table 3.4-1). Though natural variability is expected in riparian areas, the level of alteration due to timber harvest and road building is apparent.

Roads in Riparian Lands

People have often taken advantage of flat floodplains along rivers for road building, which have removed riparian vegetation. In narrow canyons with limited floodplains, roads commonly have been located on the sideslope within the riparian zone. Even in the absence of these longitudinal impacts, the continuity of the riparian corridor has been interrupted at each bridge and culvert crossing (Kondolph et al., 1996) (see Section 3.2). Consequently, roads built in riparian lands have changed riparian forest structure and composition and caused permanent land disturbance. It should be recognized that most historic management activities on private and state lands occurred under rules substantially less restrictive than are currently practiced.

The changes due to roads have caused the loss of some or all riparian functions within riparian lands depending on where road construction has occurred. One example is the loss of LWD recruitment potential from trees on the upland side of roads within riparian areas. Most of the trees on the upland side will not be recruited as LWD but are typically removed when the tree falls onto the road. Major changes to the aquatic system have also occurred from riparian land modifications due to road development, including the straightening or simplification of the stream channel system (Knutson and Naef, 1997; Beschta et al., 1995).

Currently, no specific information on statewide road density or distribution of roads in riparian areas is available. However, the National Forests have quantified the number of



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roads on National Forest System lands in Washington. For a general perspective of the rate of road building that has occurred in Washington, by 1907 only 147 miles of road had been built in all of Washington's National Forest lands. By 1962, the length of roads on National Forest System lands in Oregon and Washington had risen to 22,000-24,000 miles, and to over 90,000 miles in 1990. It was estimated that about 3,000 miles of new roads were being constructed annually in the western forested area of the United States (Knutson and Leaf, 1997). In eastern Washington increased roading has allowed greater access for forest management and some types of recreation, but it has also contributed to the protection of the forest from the spread of fires and catastrophic outbreaks of insects. Railroads were also built into some areas and eventually many railroad grades were converted to roads. The decision of where and when to build roads have always hinged on the logistics of timber harvesting (Oliver et al., 1994). As the density of roads increases, road impacts on riparian areas will inevitably be impacted (Knutson and Leaf, 1997).

3.4.3 Environmental Effects

The establishment of RMZs is generally accepted as the most effective way of protecting aquatic and riparian habitats (Cummins et al., 1994). Evaluation of the anticipated effects of the proposed alternatives on riparian habitats are based primarily on the current or proposed widths and management prescriptions within RMZs and the associated acreages of these habitats as regulated by various state management requirements.

3.4.3.1 Riparian Function Criteria

Criteria used to determine the effectiveness of proposed RMZ management allowed under each alternative, are based on the riparian functions that were summarized in Section 3.4.2 and discussed in detail in Appendix B. The effectiveness of each alternative can best be evaluated within the context of specific protection goals. Most functions are evaluated in terms of protection goals for fish and water quality. However, for microclimate, which is more likely to affect semi-aquatic species such as amphibians adversely, a variety of components was considered, including humidity, soil moisture and temperature, and air temperature. As a result, the riparian functions are evaluated in terms of the level that provides full protection relative to the specific protection goals.

The evaluation criteria are mostly defined in terms of curves, which identify the estimated relationship between the cumulative effectiveness of the riparian function and the distance from the stream bank. Therefore, these curves show the estimated degree of protection of riparian function provided by different RMZ widths. The curves are based on a wide variety of literature. However, they are generally conservative, (i.e., they reflect the widest buffers needed to provide complete protection, as identified in the literature). Note, however, that the discussions also consider lesser widths and other circumstances as appropriate. It should be noted that the relationships between distance from stream and the percent of function maintained are not all linear, and some are more theoretical in nature than based upon empirical data. In many cases, the area closest to the stream is more important for providing function than the areas further away.



Depending on the function, RMZ requirements may be defined as fixed RMZ widths or based on SPTH. A SPTH is sometimes defined as the average maximum height of the tallest dominant trees that can grow on a certain site (FEMA, 1993). However, to maintain consistency with Forest Practice Rules, SPTH in this EIS is defined as the height represented by the approximate midpoint of a stand at a given age and site condition (site class). A SPTH for Washington state varies depending on site-class, species and region (Table 3.4-2). Less productive forest lands (site class IV and V) will have shorter SPTH and more productive forest lands (site class I and II) will have taller trees. Additionally, west side trees tend to grow taller than east side trees for the same site class.

Two stand ages, 100 years and 250 years, were used to evaluate the level of protection to riparian function. A SPTH of 100 years was agreed upon by the parties to the Forests and Fish Report and was used in EIS analyses to represent a mature riparian stand. Numerous comments on the Draft EIS suggested that old-growth stand characteristics were more appropriate for use as a baseline to define adequate riparian effectiveness. Consequently, riparian function effectiveness based upon a 250-year stand was also analyzed. The choice of a 250-year stand was based upon the age at which stands begin to display old-growth characteristics (Franklin and Spies, 1991) and the return intervals for fire and blowdown reported by Agee (1993) for west side forests. SPTH were based upon Site Class II Douglas-fir stands for the west side (McArdle, 1949) and east side (extrapolated from Table I-12 in USDA Forest Service, 1984). Notably, SPTH for ponderosa pine (Meyer, 1961) at 250 years is approximately the same as for Douglas-fir on the east side. Neither of these stand age criteria have been experimentally tested for providing an adequate level of riparian function that is sufficient for maintaining robust populations of salmonids.

It is assumed that RMZ widths based on 100- and 250-year SPTHs represent the range of SPTHs over which most riparian functions are likely to be fully expressed. For example, for an east side site class II riparian area adequate protection would be provided with a buffer somewhere between 110 and 170 feet. This range represents the uncertainty about correctly choosing a particular SPTH hypothesis that provides complete protection. If a 250-year SPTH is chosen as the standard against which to compare RMZ widths, but complete protection is actually provided by a 100-year SPTH, then 60 feet of the 170-foot buffer width would represent over-protection. Conversely, if a 100-year SPTH is chosen for measuring RMZ widths, but a 250-year SPTH is the true SPTH that provides full protection, then the 110-foot RMZ would under-protect by 60 feet. It is possible that an intermediate SPTH is more appropriate or that streams with different morphological and riparian characteristics have different SPTH levels that provide full protection for that stream type.



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Table 3.4-2. Site Potential Tree Height (SPTH) for Douglas-fir at 100 years and 250 years for Western and Eastern Washington

Site Class	SPTH ₁₀₀ (feet)		SPTH ₂₅₀ (feet)	
	West Side	East Side	West Side	East Side
I	200	130	247	195
II	170	110	210	170
III	140	90	174	135
IV	110	70	136	105
V	90	60	100	85

LWD Recruitment

This evaluation is based on the level of protection provided for LWD recruitment potential from the riparian area using the RMZ width and silvicultural prescription. Based on the review in Appendix B, it was concluded that a buffer width of approximately one SPTH, is needed to provide full or maximum protection of LWD recruitment by toppling, windthrow, or stream undercutting. An exception to this may occur in second-growth stands where hardwoods have excluded regeneration of conifers or overstocking of stands have lead to the depletion of large size classes of debris (Spence et al., 1997). As a result, consideration was also given to stand manipulation to increase tree size over time. Therefore, growth rate modeling of tree diameter and age to reach functional and key piece recruitment size, based on different silvicultural prescriptions and different stream sizes was also used when evaluating alternatives (see Appendix D). The relationship between the estimated level of LWD recruitment potential and RMZ width used in the alternative evaluation is shown in Figure 3.4-1. It should be noted that most reviews of this issue demonstrate at least 70 percent of LWD is recruited within 100 feet of the stream channel (ISR, 2000; CH2MHILL, 2000); consequently, under most conditions a buffer measuring one-half site-potential tree height would provide substantially more than 50 percent protection of LWD recruitment. In order to quantify this relationship over all streams under different alternatives, an equivalent buffer area index (EBAI) was calculated for each alternative using both a 100-year and 250-year SPTH as baselines for full protection of LWD recruitment potential (see Appendix D for a full description). The EBAI provides a weighted measure of the degree of protection provided by all streams giving consideration to stream size, RMZ widths, RMZ prescriptions, source distance, and the relative length of each stream type over the landscape.

Leaf and Needle Litter Production

This evaluation is based on width of the respective RMZs and activities allowed within the buffer that may affect leaf and needle litter inputs. Little direct information is available that describes leaf and litter source distances from streams. FEMAT (1993) hypothesized that a distance of approximately 0.5 site-potential tree heights would provide most leaf and litter inputs. The estimated relationship used in this analysis is shown in Figure 3.4-2. FEMAT (1993) based this hypothesis on a study (Erman et al. 1977) of benthic invertebrate diversity in buffered and unbuffered streams in northern California. Erman et al. (1977) suggested that differences in the composition and volume of organic debris from vegetation was one of the most important factors contributing to



differences in invertebrate communities observed in these streams. Although there is some uncertainty about the validity of the leaf and litter hypothesis developed by FEMAT (1993) for use in the Pacific Northwest, it was used in this analysis because no other criteria were available.

Stream Shade

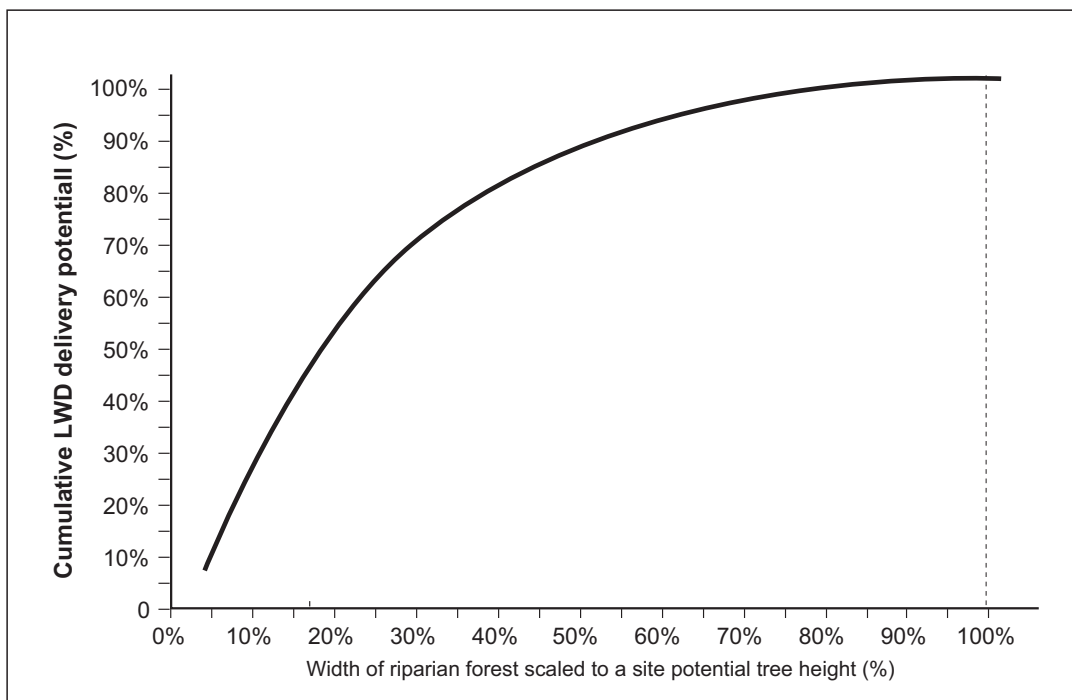
Acknowledging that there is site-specific variation that determines shade it was concluded that buffer widths of approximately 0.75 SPTH are needed to provide full protection of stream shading capacity along most perennial streams. This criteria is based upon the shade curve in FEMAT (1993). The estimated relationship used in our analysis for most perennial streams is shown in Figure 3.4-3. However, for small streams (<5 ft wide) that are often completely shaded by woody vegetation and hence have no riparian canopy opening in their undisturbed state, an RMZ width of less than 0.75 SPTH was determined sufficient to provide enough shade to maintain stream temperatures. As a result, a 50-foot buffer was used as the minimum criteria for shade along small perennial streams. For seasonal streams that do not flow during the summer, stream shade should have minimal to no effect on temperature and therefore will not be considered when evaluating shade requirements.

Microclimate

While there are not, as of yet, recommended buffer widths for maintaining microclimate gradients, the results of Brosnoff et al. (1997) and Dong et al. (1998) provide crude guidelines to evaluate the alternatives. Based on curves shown in Figure 3.4-4, a minimum of 147 feet is considered necessary to maintain most microclimatic gradients, while for air temperature, buffer widths greater than 230 feet are thought to be required.



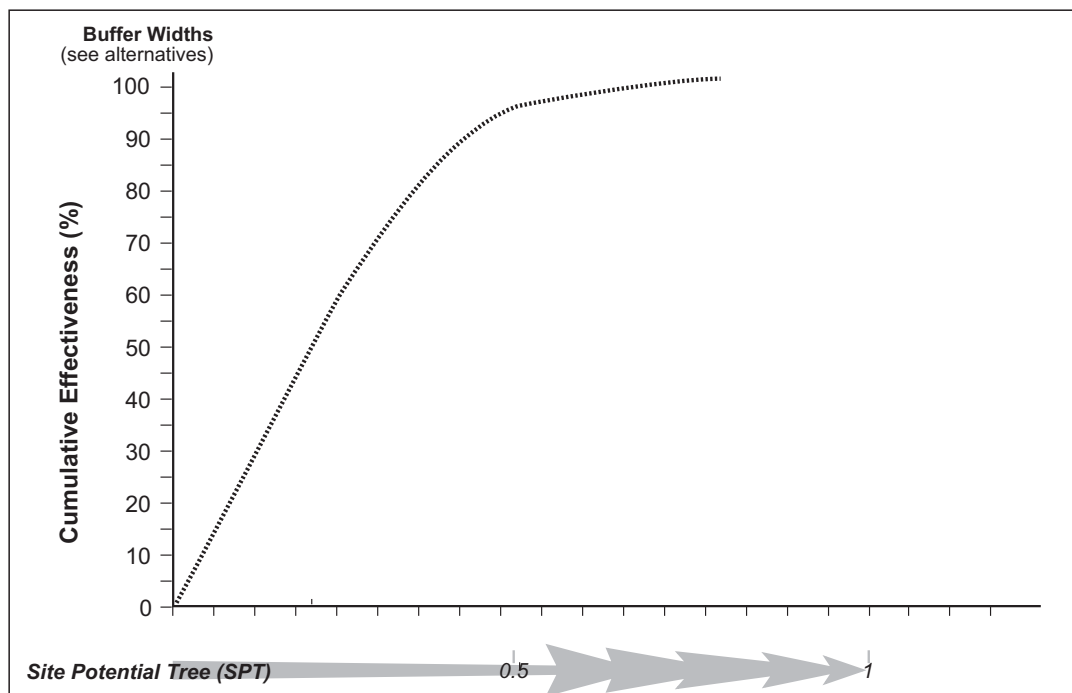
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Source: McDade et al., 1990

Figure 3.4.1

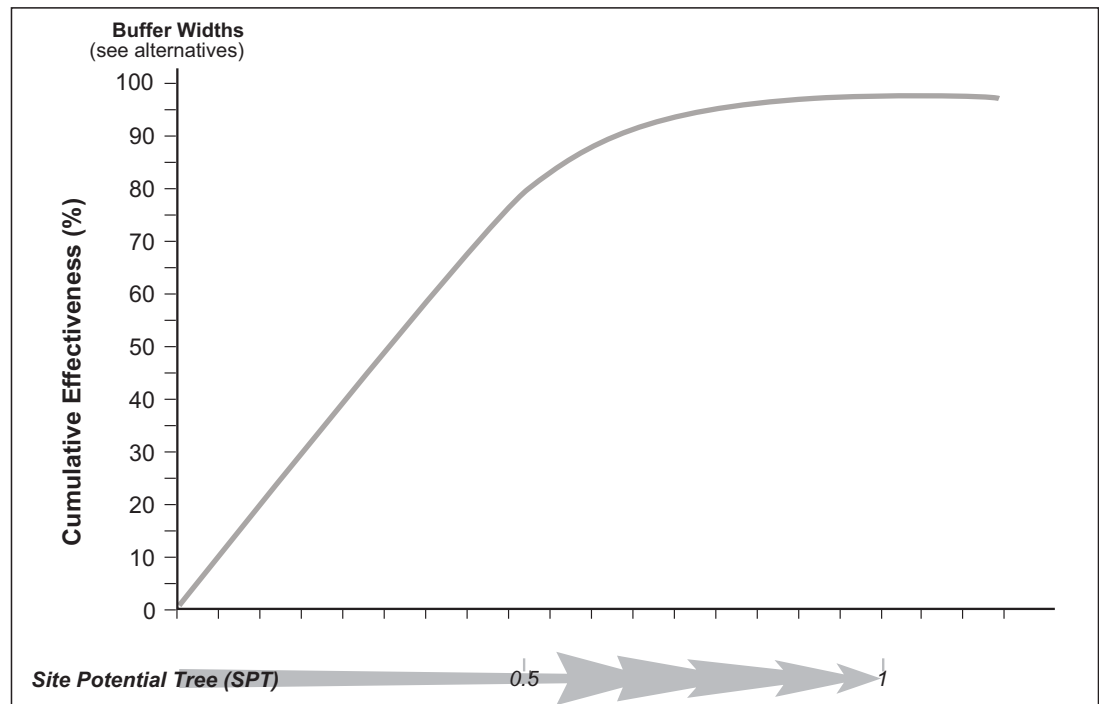
Relationship Between the Estimated Level of LWD Recruitment and RMZ Width Used in the Alternative Evaluation



Source: FEMAT, 1993

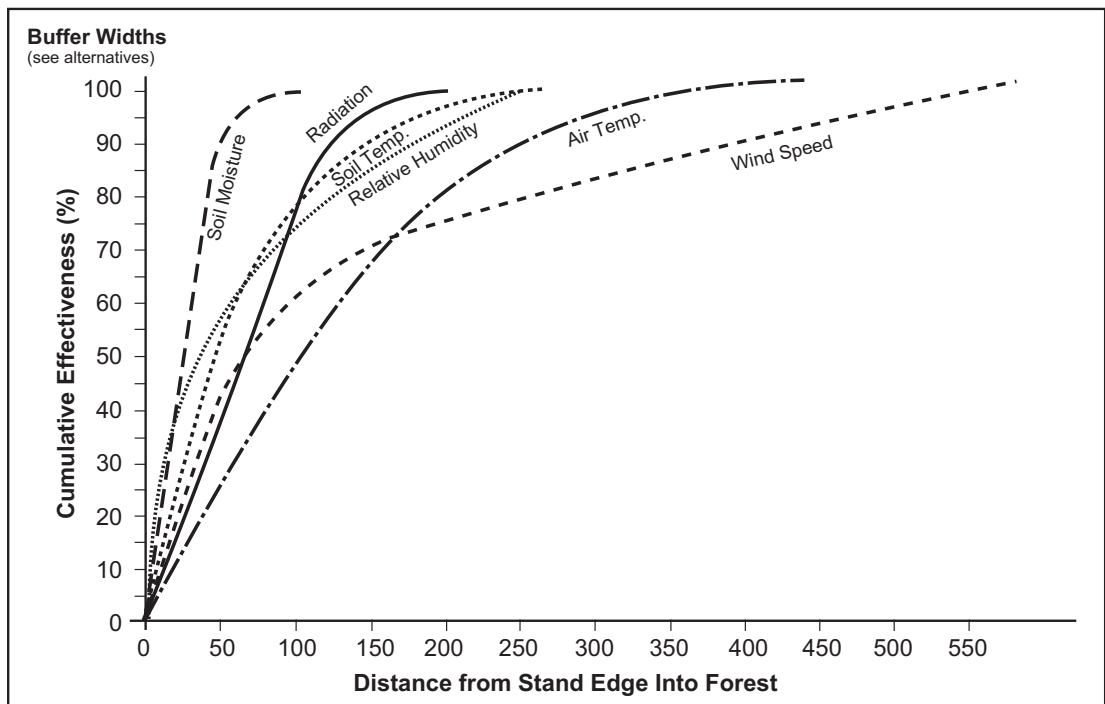
Figure 3.4.2

Relationship Between the Estimated Level of Leaf and Needle Litter Recruitment and RMZ Width Used in the Alternative Evaluation



Source: FEMAT, 1993

Relationship Between the Estimated Level of Shade Protection and RMZ Width **Figure 3.4-3**
Relationship between the estimated level of shade protection and RMZ width used in the alternative evaluation.



Source: FEMAT, 1993; Pollock & Kennard, 1999

Relationship Between the Estimated Level of Protection for Micro Climate and RMZ Width
Width Used in the Alternative Evaluation



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3.4.3.2 Evaluation of Alternatives

Because each alternative has a different stream classification scheme and different leave-tree requirements, it is difficult to quantitatively compare the effectiveness of the different alternatives in protecting riparian functions. Nevertheless, a quantitative sense of the level of protection afforded to specific processes can be gained by considering riparian buffer width together with allowable level of activity within that buffer. Therefore, for each function analyzed, an evaluation is made of both the RMZ widths and the allowable prescriptions that occur within the RMZ. Figure 3.4-5 compares the RMZ widths and the allowable prescriptions for each stream type under each alternative in western Washington, and Figure 3.4-6 provides the same comparison for the east side.

Another important aspect considered when evaluating the alternatives was susceptibility to windthrow or blowdown. If an RMZ blows down, it will not be able to maintain most of the important functions. The RMZs in all alternatives are likely to experience some degree of windthrow in localized areas. Windthrow is a normal occurrence in forests, but is known to increase along harvest unit edges after timber harvest opens formerly interior forest trees to the more direct effects of the wind (Harris, 1989). Buffer strips along streams are subject to similar increases in windthrow. Several studies have attempted to define the relationship between riparian windthrow and various physical and biological features such as topography, valley morphology, aspect, slope, soil wetness and tree type (Steinblums, 1978; Steinblums, 1984; Harris, 1989). Though these site-specific factors may increase the vulnerability of an RMZ to blowdown events, not one factor has been highlighted as of particular importance on a landscape scale. However, since blowdown is generally greater at the windward edge of a buffer, alternatives with wider buffers will provide more protection to aquatic function. Pollock and Kennard (1998) reanalyzed several windthrow data sets looking at the relationship between buffer width and the likelihood of windthrow. They reached the conclusion that buffers of less than 75 feet have a higher probability of suffering appreciable mortality from windthrow than forests with wider buffers. In general, vulnerability to windthrow tends to return to normal a few years after logging (Moore, 1977; Steinblums, 1978; Andrus and Froelich, 1986).

Data for blowdown within buffers from seven studies reported in Grizzel and Wolf (1998) had a mean blowdown rate of about 15 percent for 344 sites in western Washington and Oregon with maximum blowdown rates ranging from 17 to 100 percent in the different studies. Median blowdown rates were usually somewhat lower than the mean because the data are not normally distributed with a relatively few sites having extensive blowdown. For example, the mean blowdown rate for sites reported by Andrus and Froelich (1986) was 21.5 percent while the median value was 15.5 percent (i.e., half of the sites had less than 15.5 percent blowdown). Blowdown rates in Southeast Alaska were found to average about 9 percent in 66-foot no-harvest buffers over a four to six year period following harvest and most windthrow levels were less than 15 percent (Martin et al. 1998). Martin et al. (1998) also suggested that increased windthrow from buffers adjacent to geomorphic stream types with limited natural recruitment (via bank erosion) could be beneficial for

Figure 3.4-5. Western Washington Allowable Silviculture within RMZs by

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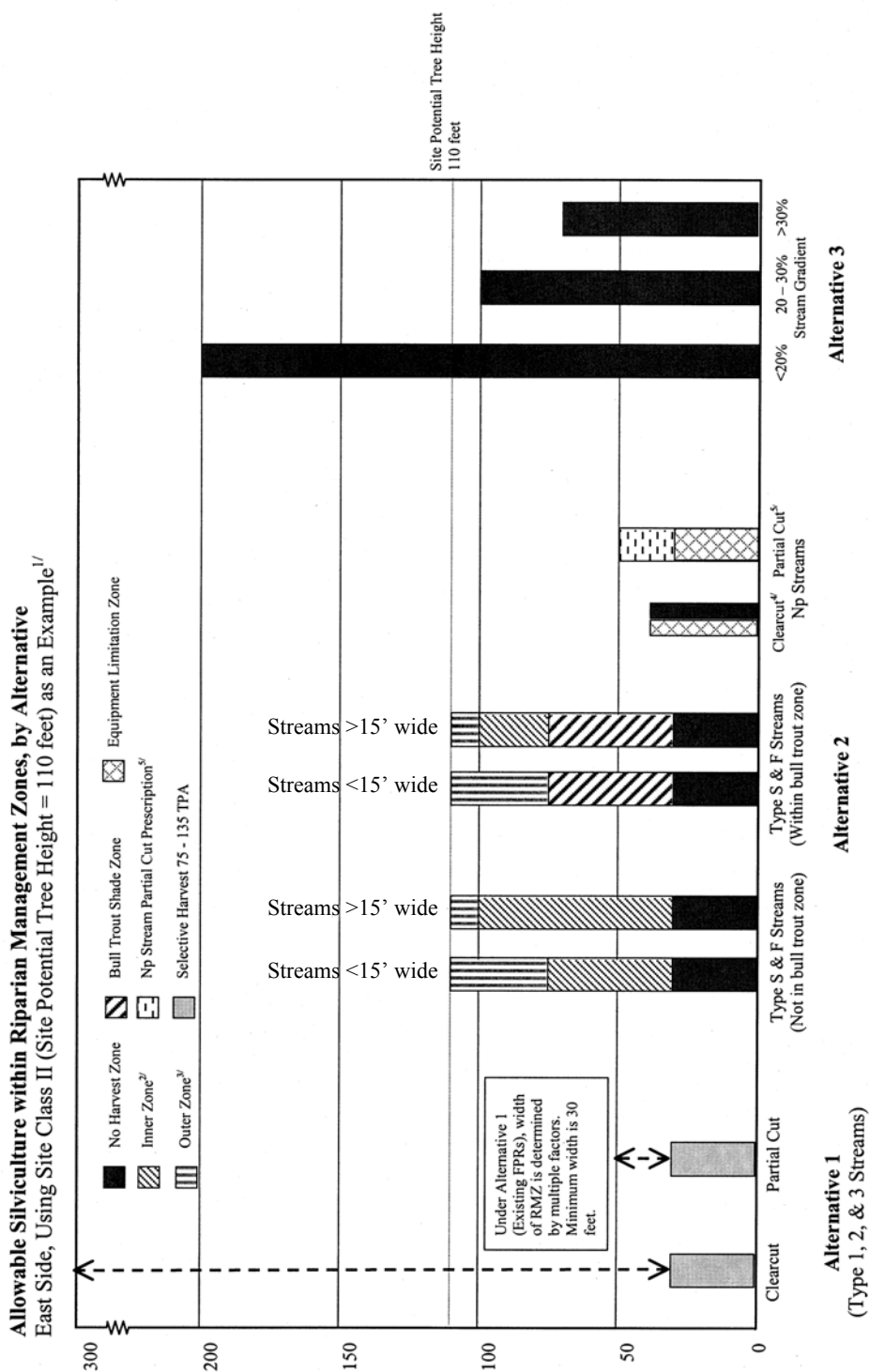


Alternative for the West Side



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Figure 3.4-6. Eastern Washington Allowable Silviculture within RMZs by Alternative for the East Side



- ^{1/} Under Alternative 2, total width of the RMZ is equal to Site Potential Tree Height, varying from 75 feet (Site Class V) to 130 feet (Site Class I). Note that the minimum RMZ width for streams greater than 15 feet wide is 100 feet.
- ^{2/} For Alternative 2 S & F streams, the Inner Zone prescription requires leaving at least 50 trees per acre after harvest, of which 21 are the largest trees, and 29 are at least 10 inches dbh. If the resulting basal area is less than 90 ft²/acre, then enough additional 10-inch-or-greater trees must be left to meet this target.
- ^{3/} For Alternative 2 S & F streams, the Outer Zone prescription requires leaving 50 trees per acre, of which 15 are at least 20 inches dbh.
- ^{4/} Clearcut strategy may be implemented in no more than 30% of the stream reach in a harvest unit, and only if an equal area is designated as a no-cut zone.
- ^{5/} For Alternative 2 Np streams in partial cut areas, leave the 10 largest trees per acre, plus as many additional trees >6" dbh as will result in a basal area of at least 90 ft²/acre.

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fish habitat. Susceptibility to blowdown is addressed as appropriate in the effects analysis using a 75-foot buffer width as a general guideline.

Evaluation of the effects of the proposed alternatives on riparian habitats is also based on a comparison of the estimated changes in total riparian area protected in some way. The estimated amount of area, presented in terms of average RMZ widths, for each protection level provided under each alternative is compared in Figure 3.4-7 for western Washington and in Figure 3.4-8 for eastern Washington (see Appendix D). The histograms presented in these figures have been standardized by estimating the total acreage in each protection category and then converting it back to the average RMZ width required to cover that acreage. Separate comparisons are shown for fish-bearing streams, nonfish-bearing perennial streams, and nonfish-bearing seasonal streams. The histograms show the different management activities allowed within the RMZ (or its zones).

Changes in riparian management and its effects on riparian habitat are addressed for the short term (10 years) and long term (50+ years). For each riparian function, the timeframe to transition from a non-functional riparian system to one that could provide most riparian functions is considered (Table 3.4-3). As discussed in Section 3.4.2 (Affected Environment), most of the riparian landscape appears not to be currently fully functioning.

Table 3.4-3. Percentage of Total Stream Miles Found in the Sample Section by Seral Stage and Estimated Time Scales for Recovery^{1/} of Each Riparian Parameter^{2/}

Seral Stage ^{3/}	Recovery Periods (in years)					
	% Seral Stage on the West Side	% Seral Stage on the East Side	Shade	LWD Recruitment	Leaf & Needle Lifter	Microclimate
Early-seral	78	61	5 to 40+ years	100+ years	30 to 80 years	10 to 40 + years
Mid-seral	21	34	20 to functioning ^{4/}	50 to 100+ years	30 to 60 years	20 to functioning ^{6/}
Late-seral	1	5	Functioning	Functioning to 100+ years ^{5/}	30 to functioning	Functioning

1/ Estimated time scales for recovery are based largely on Gregory and Bisson in Stouder et al., 1997.

2/ Hardwoods were excluded because it is unknown if they would convert to coniferous forest in the future. Site-specific investigation would be required to determine whether this is a natural condition.

3/ See Appendix A for definitions of seral stage.

4/ The upper end of the seral stage size range is functioning. The lower end of the seral stage size range requires more recovery time prior to meeting function.

5/ Functioning LWD recruitment also depends on stream size for determining recovery. Larger streams require a larger proportion of big trees and, therefore, need a longer period to recover.

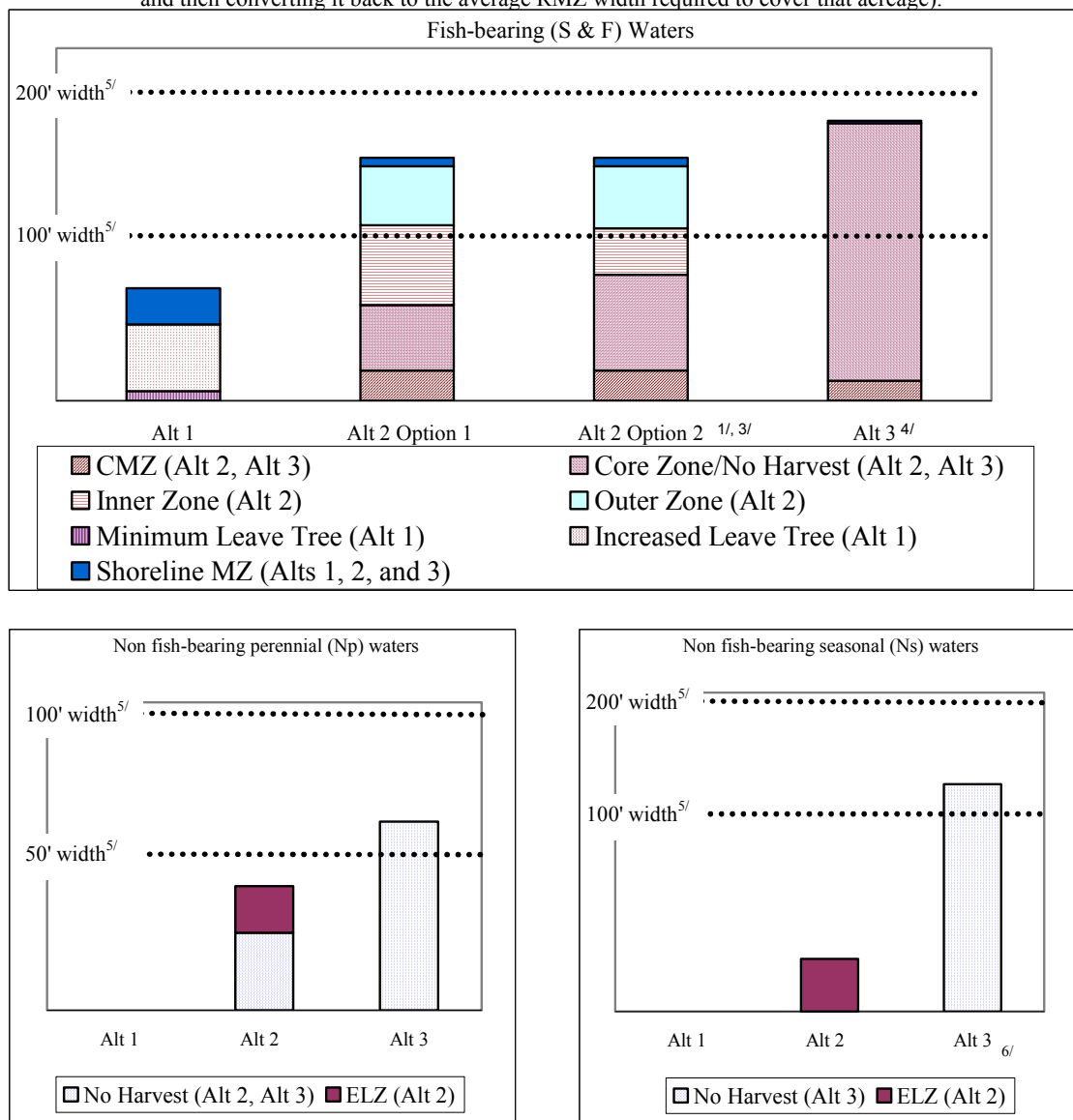
6/ Estimated to be the same time frame as shade.



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Figure 3.4-7. Total Riparian Area Protection for the West Side by Alternative

(Note: histograms have been standardized by estimating total acreage in each protection category and then converting it back to the average RMZ width required to cover that acreage).



^{1/} For Alt 2, this does not include implementing the shade rule. Also, all harvest across the landscape will be a mix of Option 1 and Option 2, rather than consisting entirely of either option; each option was modeled separately to capture the differences between the two options.

^{2/} For Alt 2 Option 1, 17% of the inner zone overlaps with the SMZ and 13% overlaps with the outer zone.

^{3/} For Alt 2 Option 2, 16% of the inner zone overlaps with the SMZ and 15% overlaps with the outer zone.

^{4/} Although most fish-bearing streams under Alternative 3 receive a 200-foot RMZ, some stream miles were greater than 20% gradient, and therefore received a RMZ less than 200 feet. This accounts for the failure of the Alt 3 RMZ acreage to meet the 200-foot buffer standard in this figure.

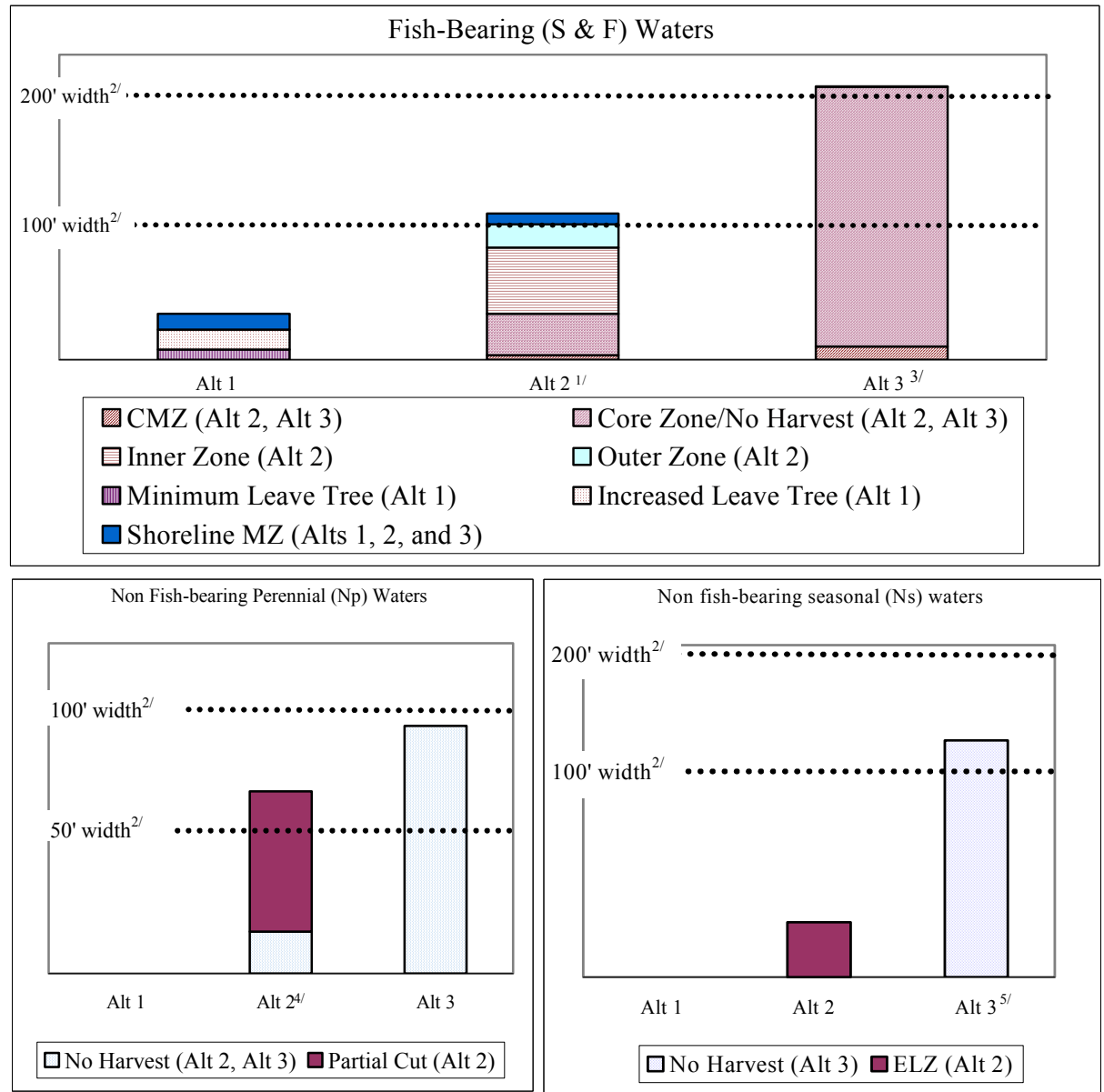
^{5/} Standardized 50', 100' and 200' buffers were applied to all stream miles, to facilitate comparison among alternatives.

^{6/} A large proportion of nonfish-bearing seasonal streams were 0-20% gradient under Alternative 3 and therefore receive a 200-foot RMZ. This accounts for Alt 3 RMZ acreage exceeding the 100-foot buffer standard in this figure.



Figure 3.4-8. Total Riparian Area Protection for the East Side by Alternative

(Note: histograms have been standardized by estimating total acreage in each protection category and then converting it back to the average RMZ width required to cover that acreage).



^{1/} The All Effective Shade requirement for bull trout may provide greater protection to 2% of Alt 2's inner zone RMZ.

^{2/} Standardized 50', 100' and 200' buffers were applied to all stream miles, to facilitate comparison among alternatives.

^{3/} Alt 3 exceeds the 200-foot standard in this figure because most fish-bearing streams receive a 200-foot RMZ, plus the CMZ acreages along some fish-bearing streams add additional acreage.

^{4/} For eastside N_p streams, 70% of the total length of stream was given a 50-foot partial cut RMZ, and 70% of the remaining 30% was given a 50-foot no-harvest RMZ (see Section 2.7.1).

^{5/} A large proportion of non-fish-bearing seasonal streams were 0-20% gradient under Alt 3 and therefore receive a 200-foot RMZ. This accounts for Alt 3 RMZ acreage exceeding the 100-foot buffer standard in this figure.



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Where some level of disturbance has occurred in riparian areas, there would be an extended period to attain desired future conditions that approach fully functioning riparian areas (Table 3.4-3). Although a large proportion of state and private lands subject to forest practices rules is currently in early seral stages (Table 3.4-1), riparian habitat should improve over time (10 to 100+ years) to increase the amount of healthy riparian areas (Table 3.4-3).

LWD Recruitment

To facilitate comparison of the LWD recruitment function among the alternatives, the EBAI for LWD was calculated and is displayed graphically in Figures 3.4-9 to 3.4-12 (see Section 3.4.3.1 and Appendix D). The EBAI analysis for LWD is applied in this section as a relative measure of the protection of streams from loss of LWD recruitment potential. The EBAI is only an approximate measure of full recruitment potential because it does not account for all factors that contribute to recruitment or reductions in recruitment of LWD. For example, the EBAI does not account for redistribution of LWD within streams, reductions that could occur from yarding corridors or roads, or LWD enhancement.

Redistribution of LWD is difficult to quantitatively model because additions in one stream section represents a loss in another. However, headwater streams can be considered net sources of LWD, if it is available for transport. Consequently, reductions in LWD recruitment in low order streams may also indicate some level of reduction of LWD recruitment to higher order streams. In coastal Oregon, preliminary results suggested LWD recruitment from upstream sources ranged between 11 and 59 percent (Gresswell and May 2000). This may be an appropriate range for basins in Washington with a similar geomorphology (i.e., steep to moderate gradient 2nd and 3rd order streams with relatively narrow valleys) and precipitation, but may be an over-estimate for other areas, particularly east side watersheds with substantially lower precipitation and likelihood of debris flows.

All of the alternatives allow yarding corridors across RMZs. Yarding corridors provide landowners flexibility in accessing and harvesting suitable timber when a road and road crossing or helicopter yarding would otherwise be required. Under Alternative 1, there are no requirements for leaving or removing trees cut for yarding corridors (presumably they would generally be removed). Under Alternative 2, trees cut in the core zone must be left, and only a volume of trees in excess of the stand requirement could be removed from the inner or outer zone. Under Alternative 3, all trees cut for the yarding corridor would remain in the RMZ. Under both Alternatives 2 and 3 any cut trees retained in the RMZ could provide potential habitat for wildlife species that utilize down wood. Yarding across fish-bearing streams requires a Hydraulic Project Approval (HPA) from WDFW. HPAs provide a regulatory mechanism for requiring mitigation for the yarding corridor and an opportunity for LWD enhancement.

Existing roads were not considered in the EBAI because they are present under all of the alternatives and their location is very site specific and difficult to incorporate in a representative fashion within the EBAI model. Incorporating existing roads would, therefore, provide additional complexity to the analysis while providing only limited additional clarity about the differences among the alternatives in terms of LWD



recruitment potential. However, the presence of roads will reduce the area available for LWD recruitment in an RMZ approximately 5 percent or less depending upon the alternative and region of the state (based on GIS analyses). Alternative 2 includes requirements that will partially mitigate for the presence of roads in the RMZ. This mitigation will be discussed below under the Alternative 2 subsection.

ALTERNATIVE 1

WEST SIDE

Type 1, 2, and 3 Waters

On the west side the current forest practices rules would provide a minimum RMZ width of 25 feet on Type 1-3 waters, with the maximum width depending on stream type and size, extent of wetland vegetation, or the width needed for implementation of the shade rule (WAC-222-30-040), ranging from 25 to 100 feet. Complete LWD recruitment potential to the stream channel for most site classes would not be maintained. The RMZs would all be less than one SPTH (both 100- and 250-year) with the exception of those on site class V lands. As indicated earlier, 100-year and 250-year SPTH assumptions were used to express the range over which full LWD recruitment is likely to be met. The 100-year SPTH assumption is derived from the Forest and Fish Report and is the basis for RMZ widths in Alternative 2 while the 250-year SPTH assumption is the age of stands beginning to display old-growth characteristics (Franklin and Spies, 1991). Based on the more prevalent site classes II and III found on state and private lands, one 100-year SPTH would equal 140 to 170 feet and one 250-year SPTH would equal 174 to 210 feet. In addition, there is an increased risk of blowdown along all streams that have an RMZ, since the average widths implemented are relatively narrow (< 75 ft) and therefore, more susceptible to blowdown. In addition, there would be no protective measures along streams with CMZs if the channel shifted to an area that was previously harvested.

Under Alternative 1, selective harvest would occur throughout the RMZ. Based on modeling (see Appendix D), the post-harvest proportion of trees of recruitable size remaining in the riparian zone would range from 7 to 74 percent (depending on site class and stream size) with a larger proportion remaining along smaller streams. Modeling involved applying prescriptions to a 50-year-old west side riparian stand, which is the stand age generally being harvested on the west side (Bolsinger et al., 1997). This analysis only considered trees left after harvest which were of a “functional” size for LWD. Though only a percentage of functionally sized LWD may actually create pools, the greater the amount recruited, the greater the potential for pool formation. For larger streams, the size of LWD would need to be substantially larger than for small streams. For example, for a stream averaging 45 feet wide, the mean diameter required for LWD has to be 22 inches compared to 8 inches in a 5-foot-wide stream.

Under Alternative 1, there are few restrictions on the harvest of large trees. Therefore, a substantial reduction in trees of functional size would occur in the RMZ. When considering key piece size (which is a subset of functional size) a much smaller proportion of trees would be left in the RMZ that would be considered large enough. The EBAI for LWD, which takes into consideration both RMZ width and the management activities that



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occur within the RMZ, demonstrates that this alternative would provide the lowest level of protection for future recruitment of LWD (see Figures 3.4-9 and 3.4-11). The 100-year and 250-year SPTH assumptions suggest that Alternative 1 will provide between 38 and 48 percent of the LWD recruitment needed on fish-bearing streams for adequate riparian function. Yarding corridors and roads would decrease these values. Under Alternative 1, no additional measures are provided to address the reduction of LWD recruitment due to these roads or future roads. In addition, there are no incentives for LWD enhancement projects, so these would rarely be implemented.

The Shoreline Management Act provides additional protection to Type 1 streams within the 200-foot shoreline management zone. However, the level of protection may decline because of the potential to re-enter the riparian area every decade for harvest.

Shorelines of the state (which are Type 1 waters) are managed under the dual jurisdiction of the Forest Practices Act and the Shoreline Management Act (SMA). During implementation of forest practices, the more restrictive of the two acts is applied along Type 1 waters. Restrictions of the Act include a 200-foot shoreline management zone (SMZ) above the ordinary high water mark that is implemented and enforced at the county level. Within the SMZ, a landowner may remove no more than 30 percent of the available merchantable trees using a selective harvest strategy. As a result, a 200-foot SMZ would complement the 25- to 100-foot RMZ applied under this alternative along shorelines of the state. Therefore, the area outside the RMZ, but within the SMZ, would receive the protection required under the SMA (see Figures 3.4-5 and 3.4-7). Under Alternative 1, the SMZ provides for substantially higher protection for Type 1 streams in the short-term than the standard forest practices rules. However, additional entries in SMZs at 10-year intervals are allowed to remove 30 percent of the standing stock of trees. Although this would tend to reduce the level of protection over time, the SMZ would continue to maintain a higher level of protection than the standard rules under Alternative 1.

On the west side, Alternative 1 would result in high risk of diminished LWD recruitment along Type 1 to 3 streams.

On the west side, most harvests occur on relatively young stands (e.g., 50 years old). Thus, the quality of LWD input would be substantially less than optimum until these areas grow to a point where trees of a sufficient size are prevalent. In addition, the current forest practices rules do not encourage improving riparian stands for long-term gains in LWD recruitment. Under this alternative, young conifer stands and hardwood-dominated stands could require many years to grow to (and may never reach) the size where they can supply functional LWD. Only along smaller Type 1 to 3 streams, would a greater proportion of the available trees function with younger stand age. Key piece size would be even more difficult to attain.



Figure 3.4-9. Equivalent Buffer Area Index (EBAI) for LWD Summed for All, Fish-Bearing, Nonfish-Bearing Perennial, and Seasonal Streams on the West Side, by Alternative Assuming a 100-year SPTH

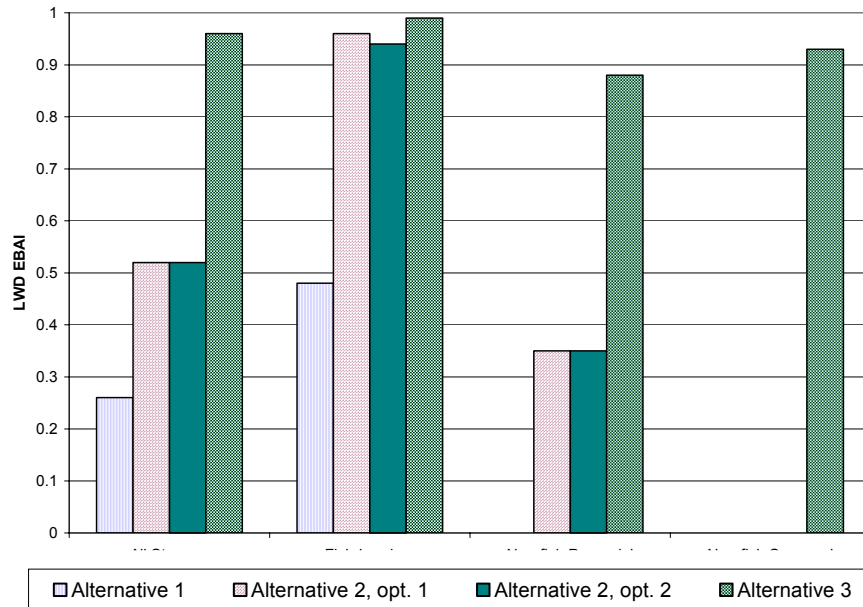
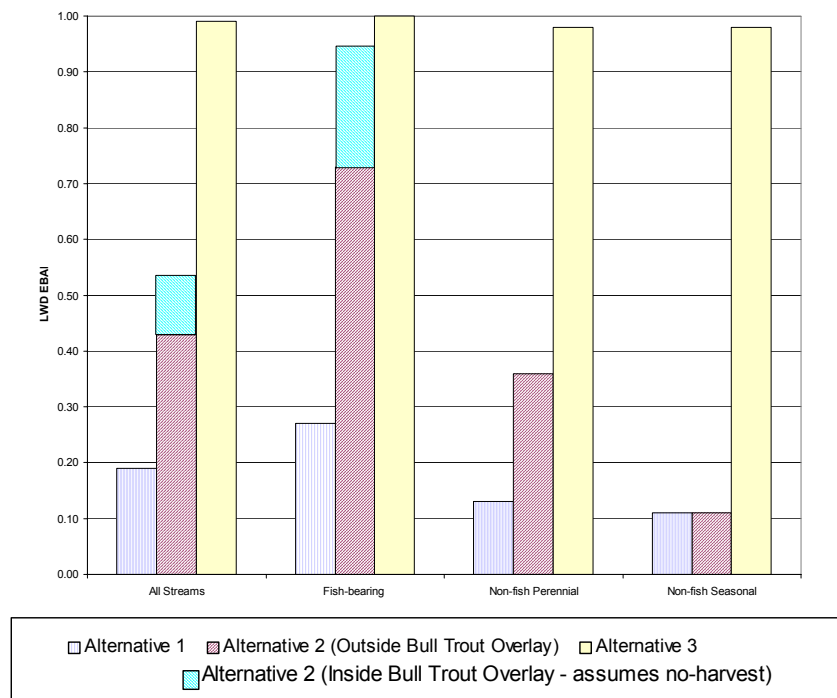


Figure 3.4-10. Equivalent Buffer Area Index (EBAI) for LWD for All, Fish-Bearing, Nonfish-Bearing Perennial, and Nonfish-Bearing Seasonal Streams on the East Side, by Alternative Assuming a 100-year SPTH





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Figure 3.4-11. Equivalent Buffer Area Index (EBAI) for LWD Summed for All, Fish-Bearing, Nonfish-Bearing Perennial, and Seasonal Streams on the West Side, by Alternative Assuming a 250-year SPTH¹

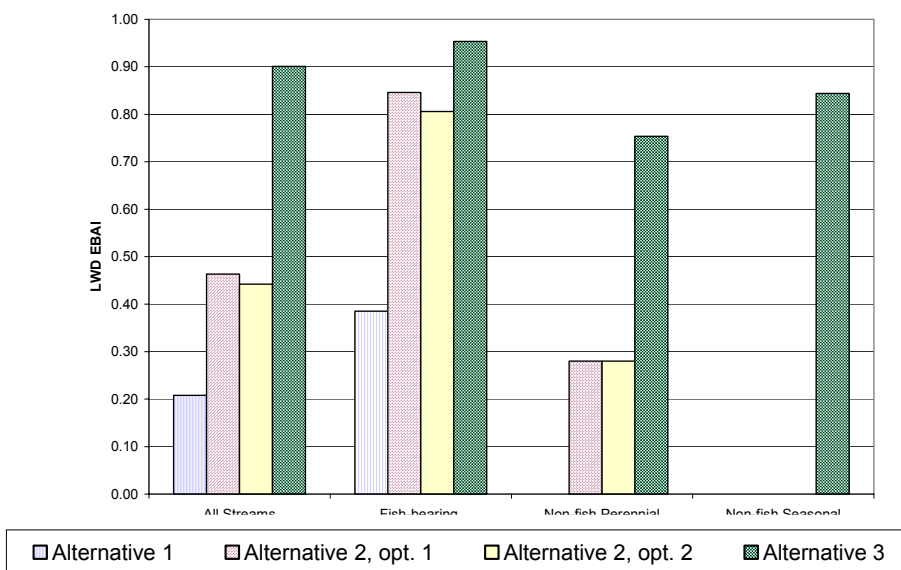
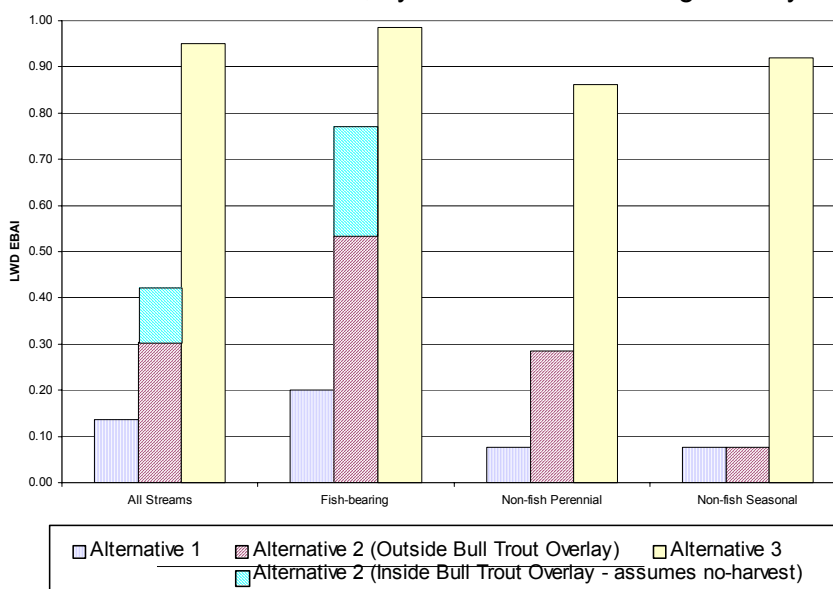


Figure 3.4-12. Equivalent Buffer Area Index (EBAI) for LWD for All, Fish-Bearing, Nonfish-Bearing Perennial, and Nonfish-Bearing Seasonal Streams on the East Side, by Alternative Assuming a 250-year SPTH²



¹ The EBAI does not include additional protection provided by the Shoreline Management Act.

² The EBAI does not include additional protection provided by the Shoreline Management Act.



RMZs are not static, since trees continue to grow where they are left in an RMZ and regeneration does occur in clear-cuts. Therefore, growth modeling was used to evaluate change over time. Based on the stands that were modeled, it is apparent that there is an increase in tree growth rate, when thinning occurs. Under Alternative 1, thinning increases the size of trees over the mid- and long-term (50-100 years). However, under Alternative 1 there is no limitation on timber harvest re-entry within the RMZ. For the west side, it was assumed that the harvest rotation averages 50 years. Therefore, long-term growth projections are unrealistic and riparian stands would not likely have enough large trees to provide for stable LWD in medium and large streams. In very large streams, (using a 120-foot wide stream as an example), trees as great as 40 inches in diameter (at a minimum) are needed as key pieces for long-term contributions to aquatic habitat. Otherwise the trees run the risk of floating away in large flood events. In addition, Alternative 1 selective harvest does not encourage riparian stand improvements within the RMZ for long-term gains, but encourages the maintenance of the status quo (i.e., maintaining the same ratio of conifers to hardwoods).

Type 4 and 5 Waters

For Type 4 and 5 waters, RMZs are not required except for site-specific conditions, and in this case would not exceed 25 feet. For Type 4 and 5 streams in most scenarios, harvest would be allowed to the stream bank. Consequently, there would be no protection of LWD recruitment potential for these smaller streams. This is shown in the EBAI for nonfish-bearing streams (Figures 3.4-9 and 3.4-11). However, there is some potential for non-merchantable trees to provide some function if left in the short-term, because of the smaller LWD needed in small streams.

On the west side, Alternative 1 would result in very high risk of diminished LWD recruitment along Type 4 and 5 streams.

Along Type 4 and 5 streams that are clear-cut to the bankfull width, long-term modeling indicated that wood of sufficient size begins to be delivered to the channel in approximately 45 to 50 years when considering both functional and key piece sizes. This was assuming an average channel width of 2 to 5 feet. If the harvest rotation rate is 50 years, minimal to no recruitment to the stream would occur over the near and long-term along Type 4 and 5 waters.

EAST SIDE

Type 1, 2, and 3 Waters

Rules for eastern Washington are generally similar to those for the west side. The RMZ width for Type 1, 2, and 3 waters ranges between 30 and 50 feet on each side of the stream for areas under the partial-cut harvest strategy, and averages about 50 feet under the clearcut harvest strategy, but can extend up to 300 feet. As for most scenarios on the west side, the range of east side RMZ widths under current rules do not maintain complete LWD recruitment potential to the stream channel because the buffers are less than one site-potential tree height (which ranges from 60 to 130 feet depending on site class for a 100-year stand and 85 to 195 feet for a 250-year stand). However, an exception occurs when riparian vegetation is extensive. In these cases the RMZ can be expanded far beyond the average 50 feet and could meet or exceed one SPTH. However, most timber harvest on the east side is selective harvest and, therefore, would not require the more expansive RMZ



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widths (see Appendix D). However, where the shade rule is implemented additional trees may be left in the RMZ. As a result, this would likely increase the proportion of recruitable trees available in the RMZ under some conditions. In addition, under Alternative 1, there is an increased risk of blowdown along all the streams that have an RMZ, since the average widths implemented (30 to 50 ft on the east side) are relatively narrow (< 75 ft) and therefore more susceptible to blowdown. Along streams with a CMZ, no additional protection of potential recruitment is provided if the channel shifts to a previously harvested area.

Similar to the west side, selective harvest can occur throughout the RMZ (Figures 3.4-7 and 3.4-8). In eastern Washington, soils and climate are less favorable for tree growth; this results in an average age of 80 to 100 years for stands at timber harvest (Bolsinger, 1997). Therefore, 80- to 100-year-old stands were used to evaluate post-harvest stand conditions after implementing the RMZ prescriptions.

Based on modeling results (see Appendix D), which implemented the selective harvest prescriptions along Type 1 to 3 streams, the post-harvest proportion of trees of recruitable size remaining in the riparian zone ranged between 12 and 73 percent on the larger streams and 35 and 74 percent on the smaller streams depending on site class and species zone (see Appendix D, Table 12). On the east side, the mean diameter required for LWD to be considered functional for a stream averaging 45 feet in width would be 12 inches, and for a stream averaging 5 feet in width it would be 8 inches (Bilby and Wasserman, 1989). Key piece size has not yet been defined for the east side, though pieces larger than what is considered functional would likely be required to provide the long-term stability that defines key piece size. Similar to functional LWD, key piece size would vary depending on channel size.

On the east side, Alternative 1 would result in high risk of diminished LWD recruitment along Type 1 to 3 streams.

For Type 1 streams, additional leave trees would likely be provided due to the Shoreline Management Act (SMA). The SMA defines a 200-foot shoreline management zone (SMZ) measured from the stream's ordinary high water mark. The SMA requires that no more than one-third of the trees within this zone be removed every 10 years using a selective harvest strategy (Figures 3.4-6 and 3.4-8). However, because the selective harvest strategy occurs more often than the even-aged strategy on the east side, additional trees outside of the RMZ, but inside the one SPTH width, will frequently be available for recruitment.

In addition, roads may be present in the RMZ. Under Alternative 1, no additional measures are provided to address the reduction of LWD recruitment due to these roads or future roads.

The EBAI for LWD under the 100-year SPTH and 250-year SPTH assumptions shows that this alternative provides the lowest level of protection overall for future recruitment of LWD when compared to other alternatives on the east side (see Figures 3.4-10 and 3.4-12 and Appendix D). LWD recruitment potential along fish-bearing streams would range from 20 to 27 percent of the levels needed for adequate protection based upon the two SPTH assumptions (see Appendix D).



On the east side under current conditions, most riparian areas are dominated by younger seral stages. Similar to the west side, the quality of LWD recruitment potential would be less than optimum. Also, similar to the west side, there is no limitation of timber harvest entry within the RMZ. For the east side it was assumed that harvest would occur every 80 years within the RMZ and the largest trees could be removed so long as leave tree requirements were met (see Table 2-2). The selective harvest prescriptions within the RMZ under Alternative 1 does not encourage improvement of the stand for LWD recruitment, but instead requires a minimum number of trees of a specific size and type along all Type 1 to 3 streams, without differentiating between stream size or riparian stand quality. Therefore, a sufficient number of larger trees in riparian stands is not likely to be maintained.

Type 4 and 5 Waters

On the east side, Alternative 1 would result in very high risk of diminished LWD recruitment along Type 4 and 5 streams.

For Type 4 and 5 streams in most scenarios, harvest would be allowed to the stream bank. However, a relatively large proportion of the east side (approximately 70 percent) usually has a selective harvest strategy that leaves some riparian trees. Along streams with a clearcut harvest strategy, there would be no protection of LWD sources and, therefore, no short-term and minimal long-term recruitment potential. Together, the EBAI suggests these harvest strategies would result in recruitment potential along nonfish-bearing streams estimated to be from 8 to 13 percent of adequate protection under the two SPTH assumptions.

ALTERNATIVE 2

GENERAL

The silvicultural prescriptions for riparian management zones (RMZs) under Alternative 2 are implemented within three zones: the core zone is nearest to the water, the inner zone is the middle zone, and the outer zone is furthest from the water. In addition to the RMZ and silvicultural prescription discussions below, it is important to note that additional measures would be implemented to replace lost LWD recruitment due to the presence of roads under Alternative 2. These mitigation measures include one of the following two measures:

- Stand requirements must be met regardless of the presence of stream crossings and stream adjacent roads; basal area shortfalls are made up in the inner and outer zones, if possible, or in nearby RMZs of the same harvest unit.
- An optional LWD placement plan (WDFW approval required) will be implemented.



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Under Alternative 2, RMZs may provide more protection than SMZs depending upon the size of the CMZ, if present. Otherwise, RMZs and SMZs would eventually provide similar levels of protection to riparian trees, depending upon the frequency and level of harvest in the SMZ. However, an SMZ would likely provide more protection to riparian trees in the short term (30 to 40 years).

The additional measures would increase future LWD recruitment potential compared to Alternative 1. The first mitigation measure would mitigate the basal area of trees lost due to the road, but would not mitigate the same level of riparian recruitment potential because the location of mitigation leave trees would be further from the stream and the mitigation leave trees have no size distribution requirements (i.e., the mitigation basal area could be reached entirely with small trees). Alternative 2 is the only alternative that provides incentives for an LWD placement plan by allowing lower leave-tree requirements in the outer zone. An LWD placement plan would increase the presence of in-stream LWD in the short-term in exchange for some trees in the portion of the RMZ that have the lowest probability of becoming in-stream LWD in the distant future. The number of trees that a landowner may remove in the outer zone depends on the plan approved by the WDFW, but leave-tree requirements cannot be reduced below 10 trees per acre.

Similar to Type 1 streams under Alternative 1, Type S streams may be provided additional leave trees under all harvest strategy options because of the Shoreline Management Act (SMA). As indicated earlier, the more restrictive rules would be implemented for any given situation where both the SMA and FPA are applied. In general, a shoreline management zone (SMZ) would likely provide more leave trees in the short-term than an RMZ, particularly for Type S streams that do not have a CMZ. An SMZ is measured from the ordinary high water mark regardless of whether a CMZ is present. Consequently, the added level of protection from an SMZ is reduced depending upon the width of the CMZ. Similar to Alternative 1, the areas outside the RMZ, but inside the SMZ, have a higher level of short-term protection due to the harvest restrictions required by the SMA. However, the level of added protection in the SMZ could decline over time because of additional harvest entries that allow removal of up to 30 percent of the trees during each decade. Nevertheless, the overall level of protection to Type S waters would be equivalent to, or higher than, the standard rules.

Landowners have the option of conducting hardwood conversion in the inner zone of the RMZ on the west side only. The riparian areas must be hardwood-dominated stands with evidence that conifers were dominant in the past. The objective of the hardwood conversion rule is to improve long-term riparian function by allowing landowners to remove hardwoods in the conversion area and restock the area with conifers. There are numerous restrictions to implementing hardwood conversion. Some of these include the following:

- The combined core and inner zone do not meet stand requirements.
- There are fewer than 57 conifer trees per acre 8 inches or larger dbh.
- There are fewer than 100 conifer trees per acre 4 inches or larger dbh.
- Conifer trees greater than 20 inches dbh shall not be harvested in the conversion area.
- No more than 10 percent of the conifer trees greater than 8 inches dbh may be harvested.



- The conversion area must be restocked with conifers and provided with post-harvest treatment.
- Conversion areas are limited to 500 feet in length.
- Landowners must own the land 500 feet above and below the conversion area.
- No stream parallel roads are present in the core or inner zone.
- Several shade restrictions apply (See WAC 222-30-021).

Because small landowners are permitted to implement less protective RMZs under Alternative 2, the risk that LWD recruitment would not be adequate to maintain a properly functioning system is increased in watersheds with large areas owned by small landowners and with high levels of past harvest.

The hardwood conversion rule represents a small risk of reducing short-term LWD recruitment potential from hardwood trees. The loss of LWD recruitment potential from harvested conifers is insignificant because most of the larger trees are protected. The conversion areas provide a small to moderate risk of reduced shade in the immediate area, but the potential adverse effects on a larger scale may be reduced by the additional shade restrictions. Conversely, the potential long-term benefit from restoring the riparian stands to conifer likely outweigh the short-term losses. As indicated earlier, conifers have the potential to provide larger and longer lasting LWD than hardwood trees (Harmon et al. 1986). Nevertheless, the DNR recognizes there is some uncertainty about the adverse effects of the hardwood conversion rule, and includes a component for tracking conversion rates on a watershed basis. The adaptive management program is charged with identifying adverse effect thresholds for conversion levels.

Under Alternatives 2 and 3, small landowners (owning less than 80 acres of forest land in Washington) would be permitted to implement substantially less protective RMZs on parcels less than 20 acres in size (see Section 2.4.2.2). Although these parcels represent a minority of the lands subject to forest practices rules (about 15 to 20 percent of all private forestlands, less if the total landbase is considered), and the rate of forest practices to be implemented on these lands is unknown, this reduced protection increases the level of concern. In watersheds with a high proportion of small landowners, especially where a high level of past harvest has occurred, this rule would increase the risk that LWD recruitment is not adequate to maintain a properly functioning system.

WEST SIDE

Alternative 2 provides two options for harvesting within the inner zone on the west side, providing that the riparian stand exceeds the requirements for meeting the desired future condition. The Option 1 approach is designed for riparian stands that have a skewed distribution with more numerous, but relatively small trees. In contrast, the Option 2 approach is designed for stands that have a more normal distribution of tree sizes. Option 1 allows harvest by thinning from below. That is, surplus basal area can be harvested, but with priority for removing smaller trees. Option 1 was developed with the objective to shorten the time required to meet large wood fish habitat and water quality needs. Option 2 allows harvest of surplus basal area by prioritizing harvest of trees furthest from the stream and leaving trees closest to the stream. The objective of Option 2 is to retain those trees closest to the stream that provide proportionally more functional benefit than trees



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farther away from the stream. As described in Chapter 2, both options have specific leave-tree requirements.

Type S and F Waters – Option 1 – Thinning From Below

On the west side, Alternative 2 specifies an overall RMZ width of one SPTH along Type S and F streams based upon a 100-year-old stand. In addition, these buffers are measured from the edge of the CMZ, where present, rather than from the edge of the bankfull channel and, therefore, provide additional protection if a shift in the stream channel occurs. Protection of the CMZ ensures that an established stand of trees would be available for recruitment in the relocated stream channel.

For Type S and F streams under Option 1, no harvest would occur in the core zone, which is 50 feet from the outer edge of either the bankfull width or CMZ (whichever is greater). Approximately 48 to 92 percent of LWD recruitment potential comes from this first zone of the RMZ, based on McDade et al. (1990), site class, and the two SPTH assumptions for stand age. For site class II, this zone accounts for 56 to 70 percent of the recruitment.

On the west side, Alternative 2—Option 1 would result in low risk of diminished LWD recruitment along Type S and F streams.

Selective harvest (thinning from below) would be allowed in the inner zone (the second zone). Specific stand requirements and thinning is based on an assessment of specific site characteristics including site class, species, trees-per-acre, ratio of hardwoods-to conifers, and average stand age, and basal area. The objective of this strategy is to shorten the time required for trees in the inner zone to reach a size adequate to provide functional LWD. This strategy allows for the removal of a portion of the smaller trees present in the inner zone leaving the largest trees which would provide all of the large tree recruitment that is available in the stand. The width of this inner zone varies depending on site class and stream size. Using a site class II modeled stand, approximately 24 to 25 percent of LWD recruitment potential comes from the 50 to 100 foot portion of the RMZ if all trees are left uncut (Appendix D). The inner zone selective harvest prescription would initially reduce the LWD recruitment potential in the RMZ inner zone by approximately 5 percent along small streams (≤ 10 feet wide) with no reduction of recruitable size trees along the larger streams. Stream size affects both LWD recruitment size and the width of the inner zone. In general, along smaller streams a wider range of tree sizes would function if recruited (i.e. smaller LWD would also be functional); therefore, a larger percentage of source trees would be lost if harvested compared to a larger river that requires larger trees to function.

The outer zone under Option 1 would provide for commercial harvest with requirements for a specific number and size of leave trees. Similar to the inner zone, the outer zone width would also vary depending on site class and stream width and would range between 22 and 67 feet. Approximately 6 to 14 percent of the LWD recruitment potential would come from the outer zone under no-harvest conditions depending upon the two site class II SPTH assumptions. Under the 250-year SPTH assumption, about 6 percent of the recruitment potential would derive from outside the outer zone (i.e., 170 to 210 feet) and would receive no RMZ protection. Based on the modeled harvest, the outer zone would contribute approximately 2 to 5 percent of the recruitment potential (see Appendix D).



The total post-harvest proportion of trees of recruitable size remaining in the three zones of the RMZ ranged between 91 percent (for smaller streams less than 10 feet wide) to 96 percent (for larger streams greater than 10 feet wide) under the 100-year SPTH assumption and between 80 to 85 percent under the 250-year SPTH assumption (see Appendix D). A sensitivity analysis was conducted using the 100-year SPTH assumption to see if the recruitment potential would vary substantially between stands on different site classes. The variation of recruitment potential based on the stands modeled (which included a low, medium and high site classes II and III) was relatively narrow, ranging between 87 and 93 percent for smaller streams and between 93 and 96 percent for larger streams (see Appendix D).

Based on the modeled harvest, the same proportion of trees sufficiently large to be considered key pieces would be present in the RMZ both pre- and post-harvest. This result occurs because the inner zone is thinned from below, leaving the largest trees in the inner zone available for potential recruitment. Therefore, depending on stream size, trees of key piece size could be maintained under this option, if they already exist in the stand. However, as stream size increases, the proportion of trees of key piece size decreases because minimum key piece size increases with stream size. This was highlighted in the sensitivity analysis where no trees of functional size (or larger key pieces) were available for recruitment along modeled site class III stands. Growth modeling using the RAIS model suggests that stands will need to be at least 160 years old to obtain key pieces for streams 44 feet wide. Therefore, the concern is over the long-term (and well beyond the expected life span of Alternative 2), since many stands do have sufficient trees of key piece size immediately after harvest.

The EBAI for LWD on the west side, shows that under both the 100-year SPTH and 250-year SPTH assumptions Option 1 would produce a substantially greater recruitment potential along Type S and F streams when compared to Alternative 1, a similar recruitment potential when compared to Option 2, and a lower recruitment potential when compared to Alternative 3 (Figures 3.4-9 and 3.4-11). In addition, it is clear that fish-bearing streams are provided more protection than nonfish-bearing streams under this alternative. However, the EBAI does not take into consideration the long-term benefits associated with thinning to boost the growth rates of source trees remaining in the RMZ. Therefore, long-term modeling was implemented to evaluate the change over time.

The current quality of LWD input potential along most west side streams is well below the optimum, and will remain that way until riparian areas grow to a point when trees are of sufficient size to provide functional LWD recruitment. The 50-year old stand modeled for long-term recruitment using the Riparian Aquatic Interaction Simulator (RAIS) demonstrate there is an increase in tree growth rate under Option 1. However, the modeling suggested that thinning adjacent to small streams (< 10 ft) would not result in a decrease in the time required for trees to reach a functional size (about an 80-year old stand, regardless of thinning). In addition, a wider range of tree sizes along small streams would provide functional LWD if recruited; therefore, a larger percentage of potential source trees would be lost if harvested. However, the benefit of thinning appears to be substantial when considering large streams and key piece size, especially in high



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Based on long-term modeling, Option 1 (thinning from below) would shorten the time required to obtain key piece size LWD, particularly on productive sites along large streams. Along small streams, thinning does not appear to benefit key piece size LWS recruitment and may hinder it.

On the west side, Alternative 2—Option 2 would result in low risk of diminished LWD recruitment along Type S and F streams.

productivity stands (100-year site index of 128 or greater). For the streams 44 feet wide, the modeling suggested that compared to no harvest, thinning resulted in a shorter time period for the growth of trees large enough to serve as key pieces (160-year stand if thinned and 290-year stand with no harvest). In addition, the modeling suggested there could be an increase in the amount of LWD. The RAIS model indicated that a 300-year old, site class II stand would have about 14 percent (nearly 2 pieces per 1000 feet) more functional LWD following thinning under Option 1 compared to Option 2 or Alternative 3. The modeling suggests that for lower productivity riparian stands or streams less than 30 feet wide, thinning does not provide a substantial benefit for producing functional and key piece LWD at a more rapid rate than no-harvest.

Type S and F Waters – Option 2 – Leaving Trees Closest to the Water

Under Option 2, no-harvest buffers are 80 feet wide on streams less than 10 feet wide and 100 feet wide on streams greater than 10 feet wide. Similar to Option 1, no harvest would occur under Option 2 in the 50-foot-wide core zone measured from the bankfull width or CMZ (if present). Consequently, the core zone would provide the same level of protection under Option 2 as it would under Option 1 (48 to 92 percent under the two SPTH assumptions and five site classes; Figures 3.4-1). In addition, to the core zone, the next 30 feet of the inner zone on streams less than 10 feet wide and 50 feet on streams greater than 10 feet wide, would also have no-harvest. Option 2 can only be applied to Site Class I, II and III areas on streams less than or equal to 10 feet wide and Site Class I and II areas on streams greater than 10 feet wide. Depending upon the SPTH assumption (for site class II), the combined no-harvest buffers from the core zone and inner zone ranged from 73 to 86.5 percent of full LWD riparian function for smaller streams (< 10 feet) and 80 to 95 percent of full function for larger streams.

Selective harvest would be allowed in the remaining portion of the inner zone, which varies in width, depending on site class and stream size. When modeled, the total inner zone recruitment potential for streams greater than 10 feet wide would be maintained. For streams less than or equal to 10 feet a reduction of approximately 3 percent of trees of recruitable size would occur. Under Option 2, if prescriptions in the core and inner zone result in a basal area that exceeds the basal area target, a greater reduction of trees is allowed in the outer zone. In the modeled example, there was no excess (i.e., all 20 trees per acre were retained) resulting in a range of 0 to 2 percent of the recruitable trees remaining, depending on stream size. The leave tree requirement for the outer zone can also be reduced if conifers are retained in the CMZ.

The post-harvest proportion of trees of recruitable size remaining in the combined three zones of the RMZ ranged between 94 and 95 percent of the pre-harvest condition (see Appendix D). The overall recruitment potential of smaller streams (<10 ft) under Option 2 was higher than the recruitment potential under Option 1. In contrast, Option 1 produced greater recruitment potential for larger streams (> 10 ft). However, the differences between the two options were not large, less than 3 percent of the pre-harvest potential.

Consequently, the different strategies do not appear to substantially change the amount of recruitable size trees. A sensitivity analysis using the 100-year SPTH assumption and site

Based on long-term modeling, Option 2 would take longer to produce key piece size LWD

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Based on long-term modeling, Option 2 would take longer to produce key piece size LWD than Option 1 along longer streams; however, for smaller streams, Option 2 would produce greater quantities earlier.

class III (low) to site class II (high) showed similar patterns. The differences between options were 5 percent or less and both options left 87 percent or more of the recruitable sized trees.

Under Option 2, the EBAI ranged from 81 to 94 percent for fish-bearing (Type S and F) streams under the 250-year SPTH and 100-year SPTH assumptions, respectively. The EBAI under both SPTH assumptions, suggests that Option 2 of Alternative 2 would produce a substantially greater recruitment potential along Type S and F streams compared to Alternative 1, a similar recruitment potential compared to Option 1, but a lower recruitment potential compared to Alternative 3 (Figure 3.4-9 and 3.4-11).

One limitation of the EBAI is that it fails to take into consideration the growth rate of trees remaining in the RMZ after silvicultural prescriptions are applied. Stand growth modeling suggests the rate of growth is slower with the wider no-harvest area of Option 2 compared to Option 1. Consequently, under this option, wider streams will require a longer period of time to produce the larger trees needed to provide LWD function. However, for smaller streams where smaller size LWD is needed to provide function, this option would ensure a greater number of source trees left in the RMZ for recruitment.

There is high uncertainty regarding the impact of low LWD recruitment along small, nonfish-bearing streams on downstream fish habitat.

Nonfish-bearing Waters

On portions of Type N_p streams, RMZ widths would be 50 feet, which is less than the one site-potential tree height (both 100-year SPTH and 250-year SPTH) recommended in most literature to encompass the source area where an adequate level of LWD recruitment can occur. The 50-foot buffer would provide for approximately 48 to 92 percent of recruitment potential of a mature stand where the buffer is implemented, depending upon site class (McDade et al., 1990). At least 50 percent of the length of N_p streams, which include all sensitive sites within the harvest unit, are required to have the 50-foot no-harvest RMZ. Depending on the number of sensitive sites more than 50 percent of the N_p streams could be given an RMZ. Because of the relatively narrow buffer strip, there is a greater risk of blowdown occurring. As mentioned previously, observed blowdown levels average about 15 percent, but vary widely depending upon site characteristics and could approach 100 percent in rare circumstances. On Type N_s and all other Type N_p streams, harvest would be allowed to the stream bank. Therefore, there would be no protection of LWD recruitment potential.

On the westside, Alternative 2 would result in moderate to high risk of diminished LWD recruitment along perennial nonfish-streams and no protection along seasonal nonfish-streams.

Currently, the contribution of LWD from Type N_p and N_s streams to Type S and F (fish-bearing) streams is not well understood, but Type N_p and N_s streams are known to supply at least some level of LWD to downstream fish-bearing streams (Potts and Anderson, 1990). In narrow coastal streams in coastal Oregon, movement of LWD in second- and third-order streams has been observed to range between 11 and 49 percent (Gresswell and May 2000). In some streams, the level of input can be very high as a result of debris torrents. In addition, trees that fall into streams are important for sediment retention (Keller and Swanson, 1979; Sedell et al., 1988), gradient modification (Bilby, 1979), and nutrient production (Cummins, 1974) in Type N_p and N_s streams.



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EAST SIDE

Type S and F Waters

On the east side, Alternative 2 specifies an RMZ width of at least one SPTH along Type S and F streams. There are a few exceptions, which include streams less than 15 feet wide that are on site class V soils and streams greater than 15 feet wide that have a site class of III, IV or V (which all exceed one SPTH). Therefore, Type S and F stream RMZs meet the width recommended in the literature for LWD recruitment. In addition, because these buffers are measured from the CMZ or the bankfull width, there is an additional factor established for the possibility of a shift in the stream channel. This would ensure that an established stand of trees would be available for recruitment in the relocated stream channel.

For Type S and F streams, no harvest would occur in the core zone, which is 30 feet from the CMZ or bankfull width. Approximately 65 percent of LWD recruitment potential comes from the core zone within the RMZ, based on McDade et al. (1990) using a 100-year SPTH of 110 feet and 44 percent of the recruitment potential using a 250-year SPTH of 170 feet.

Selective harvest would be allowed in the inner zone, which varies in width, measured from the outer edge of the core zone, depending on stream width. For streams less than 15 feet wide, the inner zone would be 45 feet wide and for streams greater than 15 feet wide the inner zone would equal 70 feet. Using a site class II modeled stand for comparative purposes, approximately 31 (100-year SPTH) to 33 (250-year SPTH) percent of LWD recruitment potential would come from the 30 to 75-foot zone of the RMZ if all source trees are left uncut along a stream less than 15 feet wide. Streams wider than 15 feet would have approximately 33.5 (100-year SPTH) to 42 (250-year SPTH) percent of recruitment potential from the 30 to 100-foot inner zone of the RMZ. The inner zone selective harvest prescription (using the modeled stand) would maintain 8 (100-year SPTH) to 9 (250-year SPTH) percent of the no-harvest LWD recruitment potential along streams less than 15 feet wide. For streams greater than 15 feet wide, the inner zone selective harvest prescription would maintain between 6 (100-year SPTH) and 14 (250-year SPTH) percent of the LWD recruitment potential.

More restrictive prescriptions will be implemented within the bull trout overlay. The bull trout overlay means those portions of eastern Washington streams containing bull trout habitat as identified on the Department of Fish and Wildlife's bull trout map. The more restrictive prescriptions are designed for a higher level of protection for trees that provide shade, but would also provide increased protection for trees that could become LWD. In areas where the bull trout overlay would be applied, the inner zone was modeled as no-harvest between 30 and 75 feet for all streams to capture the maximum likely shade-retention strategy. For streams greater than 15 feet wide, the area 75 to 100 feet from the stream or CMZ edge was modeled as a partial harvest leaving at least 50 trees per acre including the 21 largest trees, at least 29 trees greater than 10 inches dbh, and basal area of at least 90 ft² per acre leave trees. Under this scenario, 31 (100-year SPTH) to 36 (250-



year SPTH) percent of the no-harvest LWD recruitment potential would come from the inner zone (see Appendix D, Table 31a and 31b).

The outer zone has prescriptions that allow for a more intensive selective harvest. Similar to the inner zone, the outer zone width would also vary, depending on site class and stream width, and ranges between 0 and 55 feet. The outer zone provides approximately 1.5 (100-year SPTH) to 2.5 (250-year SPTH) percent of the LWD recruitment potential if all source trees are left uncut. Under the 250-year SPTH assumption for site class II soils, about 11.5 percent of the recruitment potential derive from outside of the outer zone (i.e., 110 to 170 feet) and receive no RMZ protection. The outer zone would maintain less than 1 percent of the recruitment potential under the 100-year SPTH assumption, but would provide about 2 percent of the potential under the 250-year SPTH assumption. This results from the different cumulative recruitment potential curves used under the two assumptions. The 100-year SPTH assumption was based upon the mature stand and the 250-year SPTH assumption was based upon the old-growth curve from McDade et. al (1990). Compared to the mature curve, the old-growth curve has a higher percentage of the total recruitment derived farther from the stream.

On the east side, Alternative 2 would result in moderate risk of diminished LWD recruitment along Type S and F streams.

With all zones combined, in areas outside the bull trout overlay the post-harvest recruitment potential for trees of recruitable size remaining in the three zones of the RMZ would range from 55 (250-year SPTH) to 74 (100-year SPTH) percent of the no-harvest potential for smaller streams less than 15 feet. The range for larger streams greater than 15 feet was 52 (250-year SPTH) to 76 (100-year SPTH) percent (see Appendix D). In areas within the bull trout overlay, the post-harvest recruitment potential of trees of recruitable size ranges from 80 (250-year SPTH) to 96 (100-year SPTH) percent for streams less than 15 feet and 79 (250-year SPTH) to 97 (100-year SPTH) percent for streams greater than 15 feet.

A sensitivity analysis was prepared using the 100-year SPTH assumption to determine the variation among post-harvest recruitment potential between vegetative habitat types (mixed conifer versus ponderosa pine), areas within or outside the bull trout habitat overlay, site classes, and stream size. The results suggested there were moderate differences between vegetative habitat types (8 percent or less), large differences (10 to 28 percent) between areas in or out of the bull trout overlay, large differences (up to 19 percent) between site classes, and small differences (less than 5 percent) between stream sizes (see Appendix D). For both the mixed conifer and ponderosa pine habitat types the post-harvest LWD recruitment potential was consistently higher on sites with lower productivity (see Appendix D). This can be explained by the fact that sites with lower productivity (e.g., site class IV and V) have a lower SPTH than those with higher productivity. Therefore, the 30-foot core zone represents a greater percentage of the total SPTH and recruitment potential.

Also, for most of the stands modeled in the sensitivity analysis, it was apparent that larger streams that require large wood (greater than 10 inch dbh) to function, may not benefit from the 29 smaller trees retained in addition to the 21 largest trees (in order to make up the minimum of 50 trees per acre) retained in the inner zone over the short term.

Recruitment potential for these larger streams would likely only come from the 21 largest



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trees per acre left in the RMZ until the rest of the trees grew to a size that would provide function when recruited. This disparity would likely be even larger for the recruitment of key piece LWD. For these large streams, depending on the size class distribution in the stand, there is a greater risk of recruitable sized trees being harvested that fall in between the gap of the minimum size trees that are retained (10 inch dbh) and the largest trees in the stand that are required to be retained. Mid-size streams, with a wider inner zone compared to streams less than 15 feet wide, would have the lowest risk of LWD recruitment loss over the short-term, though some reduction would occur.

The EBAI for LWD weights the recruitment potential for each stream type and size by the length of the stream in those categories and provides an overall measure of recruitment potential by alternative. The EBAI for LWD on the east side outside of the bull trout overlay ranges from 54 (250-year SPTH) to 73 (100-year SPTH) percent of the no-harvest potential along Type S and F streams. The EBAI suggests that under the protection levels provided outside the bull trout overlay, there is a substantially greater recruitment potential along Type S and F streams under Alternative 2 compared to Alternative 1, but less when compared to Alternative 3 under both SPTH assumptions (Figures 3.5-10 and 3.5-12).

On the east side, thinning in the inner zone would likely shorten the time required to obtain key piece size LWD over the long term, except along small streams that require smaller size LWD.

Within the bull trout overlay, which covers most of the east side forested areas, if a landowner decides not to harvest any trees within 75 feet of the stream to address shade issues (see the stream shade section, below), then the level of protection would increase substantially over the standard rule. Notably, shade producing trees in the inner zone are also those most likely to be the larger trees that would also provide LWD if they fall into the stream. Under this assumption, the EBAI for LWD ranges between 78 (250-year SPTH) and 96 (100-year SPTH) percent of the no-harvest potential. In practice, it is expected that most landowners would harvest some trees between the core zone and 75 feet and the level of protection would thus be intermediate between the standard rule and the potential protection available from the shade rule.

The EBAI under the 250-year SPTH assumption is substantially lower (about 18.5 percent) than the 100-year SPTH assumption. Consequently, there is substantially more risk if a 250-year SPTH is more appropriate for describing the buffer width needed for full protection of LWD recruitment. Overall, there is a moderate (100-year SPTH assumption) to high (250-year SPTH assumption) level of risk that LWD recruitment potential to Type F and S streams may not be at levels adequate to sustain robust salmonid populations, except in situations where implementation of the shade rule results in substantial harvest reductions within the 75-foot bull trout overlay zone.

On the east side under current conditions, most riparian areas are dominated by forests in early seral stages. Thus, the quality of LWD input potential is currently less than optimum to provide LWD recruitment. Using the RAIS growth modeling to predict tree growth rate, it is apparent that thinning results in increasing tree diameter at a faster rate. Under Alternative 2, thinning the inner zone increases the size of trees over the mid- and long-term, producing larger trees sooner (see discussion under west side). However, because the growth rate is slower on much of the east side, the time-frame would likely be extended. Though key piece sizes have not been calculated for the east side specifically, the time that

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key piece size is achieved would also likely be reduced to some extent, similar to the west side. However, the actual timeframe required to reach key piece size would likely be longer than for the west side. For the larger streams there may be a greater lag time before a larger proportion of trees would be of recruitable size, since the medium/large size trees are at the greatest risk of reduction in the short-term.

Nonfish-bearing Waters

On the eastside, Alternative 2 would result in moderate risk of diminished LWD recruitment along perennial non-fish streams and high risk along seasonal non-fish streams.

On Type N_p streams, the RMZ width would be 50 feet. The silvicultural prescription for the Type N_p RMZ can be partial cut, clearcut, or no harvest and are designated as part of a timber harvest application. The RMZ is less than the one site-potential tree width recommended in most literature to encompass the entire source area. The 50-foot buffer would provide for approximately 48 to 92 percent recruitment potential, depending upon site class and SPTH assumption (McDade et al., 1990). On some N_p and all N_s stream reaches, harvest would be allowed to the stream bank. Consequently, there would be no protection of LWD recruitment potential along these stream reaches. Trees along Type N_p and N_s streams (like Type S and F streams) that fall in are important for sediment retention (Keller and Swanson, 1979; Sedell et al., 1988), gradient modification (Bilby, 1979), and nutrient production (Cummins, 1974).

Because small landowners are permitted to implement less protective RMZs under Alternative 2, the risk that LWD recruitment would not be adequate to maintain a properly functioning system is increased in watersheds with large areas owned by small landowners and with high levels of past harvest.

Silvicultural prescriptions within buffers along Type N_p streams include a partial cut and a clearcut option. The partial-cut option has a selective harvest prescription similar to the inner zone along Type S and F streams. The clear-cut option can be implemented along no more than 30 percent of the stream reach within the harvest unit, cannot be more than 300 feet in length, and must be at least 500 feet upstream from the an intersection with a Type S or F stream. A no harvest prescription must be implemented on both sides of the stream over a length similar to that implemented for the clearcut prescription. Under the partial cut option, 24 to 36 percent of the recruitable trees were left in the RMZ depending on site-class and species zone under the 100-year SPTH assumption. Once a partial cut or clearcut strategy is selected, it cannot change during the life of the Alternative 2 plan. Under the clear-cut option 55 to 59 percent of the recruitable trees were left in the RMZ. For all Type N_s streams, no RMZs are maintained, and, therefore, no protection of LWD recruitment potential would occur.

ALTERNATIVE 3

GENERAL

As for Alternative 2, the small landowner exemption would apply to the riparian rules under Alternative 3. Small landowners (owning less than 80 acres of forest land in Washington) would be permitted to implement substantially less protective RMZs on parcels less than 20 acres in size (see Section 2.4.2.2). Although these parcels represent a minority of the lands subject to forest practices rules (about 15 to 20 percent of all private forestlands), this reduced protection increases the level of concern. In watersheds with a high proportion of small landowners, especially where a high level of past harvest has occurred, this rule would increase the risk that LWD recruitment is not adequate to maintain a properly functioning system.

Alternative 3 provides more protection for riparian trees along shorelines of the state than the SMA.



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Under Alternative 3, the Shoreline Management Act (SMA) would not provide any additional protection to riparian trees along shorelines of the state compared to the standard rules. In fact, the standard rules under Alternative 3 would provide a greater level of protection than the SMA because the 200-foot RMZ is a no-harvest buffer and measured from the outer edge of the channel migration zone.

On the west side, Alternative 3 would result in low risk of diminished LWD recruitment along fish-bearing streams.

On the west side, Alternative 3 would result in low risk of diminished LWD recruitment along nonfish-bearing streams.

Because small landowners are permitted to implement less protective RMZs under Alternative 3, there is some risk of diminished LWD recruitment in watersheds with large areas owned by small landowners and with high levels of past harvest.

Based on long-term modeling, it is apparent that LWD diameters increase faster when thinning is implemented; generally larger streams would benefit from thinning and smaller streams would benefit from no harvest.

WEST SIDE

On the west side, Alternative 3 would implement 200-foot RMZs along streams less than 20 percent gradient, 100-foot RMZs along streams 20 to 30 percent gradient, and 70-foot RMZs along streams greater than 30 percent gradient. These RMZs would provide 94 to 100 percent, 75 to 100 percent, and 62 to 98 percent of the recruitment potential, respectively, depending upon the SPTH assumption for site class. Similar to Alternative 2, additional protection of LWD recruitment potential is provided by measuring the RMZ from the channel migration zone (CMZ). Other zones that would provide additional protection of recruitment potential include measuring the RMZ from beaver habitat zones (BHZs) and channel disturbance zones (CDZs). These no-harvest zones would provide additional LWD recruitment potential in areas that are not protected under Alternatives 1 and/or Alternative 2. Also, because of the relatively wide RMZs under Alternative 3, the risk of blowdown would be relatively low compared to the other alternatives.

For all three stream types, no harvest is allowed within the RMZ except for specific cases which include 1) converting a hardwood-dominated stand to one that is conifer-dominated, or 2) facilitating the development of 200 year-old stand conditions. As a result, most if not all of the recruitment potential based on RMZ width (described above) would be maintained unless stand manipulation was deemed necessary to facilitate riparian condition.

Under both the 100-year and 250-year SPTH assumptions, the EBAI analysis suggests that Alternative 3 has the greatest recruitment potential along all streams when compared to Alternative 1 and Alternative 2 (Figures 3.4-9 and 3.4-11). In addition, the EBAI suggests that recruitment potential to fish-bearing streams would be about 95 percent or higher. Although the higher gradient streams do not fully meet the one SPTH width to provide complete recruitment potential, virtually all high gradient streams are nonfish-bearing. However, a large proportion (70 percent) of the low gradient streams modeled (see Appendix C) fall in the category of N_s streams under Alternative 2. Therefore, a relatively large proportion of streams that would likely be categorized as seasonal streams (and receive no buffer under Alternative 2), would receive a 200-foot, no-harvest RMZ under Alternative 3. This factor produces a substantial increase in the EBAI value when compared to the more limited protection provided these streams under Alternative 2 and Alternative 1 (see Appendix D and Figures 3.4-9 and 3.4-11).

Using growth modeling, it is apparent that tree diameters increase at a faster rate when thinning is implemented. Therefore, the riparian stands that are along larger streams, thinning as provided by Option 1 of Alternative 2 may be important to increase the growth rate over a shorter period of time depending on the channel condition. However, along the



smaller fish-bearing and nonfish-bearing streams that do not necessarily benefit from thinning, this alternative provides the maximum recruitment potential.

EAST SIDE

Silvicultural prescriptions in RMZs are the same on the east side as on the west side. However, SPTH is less than on west side. Therefore, there are some differences in the level of protection for LWD recruitment potential. On the east side, Alternative 3 would provide 100 percent of LWD recruitment potential through the designation of a 200-foot RMZ along streams that are less than 20 percent in gradient under all site classes and both the 100-year and 250-year SPTH assumptions. For the 100-foot RMZ on streams that are between 20 and 30 percent gradient, LWD recruitment potential would range from 98 – 100 percent for the different site classes under the 100-year SPTH assumption and between 81 and 100 percent for the different site classes under the 250-year SPTH assumption. Under the 250-year SPTH, 100 percent of LWD recruitment potential would occur for site class V soils, but site class III and IV soils would exceed 90 percent of LWD recruitment potential. The RMZs along streams that are greater than 30 percent would result in 91 to 100 percent of recruitment potential under the 100-year SPTH assumption and 71 to 94 percent of LWD potential under the 250-year SPTH assumption. Similar to Alternative 2, additional protection of LWD recruitment potential is provided by measuring the RMZ from the CMZ and ensuring no-harvest within the CMZ. Other zones that would provide additional protection of recruitment potential include measuring the RMZ from BHZs and CDZs where they apply. Also, because of the relatively wide RMZs under Alternative 3, the risk of blowdown would be relatively low.

On the east side, Alternative 3 would result in low risk of diminished LWD recruitment along fish-bearing streams.

On the east side, Alternative 3 would result in low risk of diminished LWD recruitment along nonfish-bearing streams.

Because small landowners are permitted to implement less protective RMZs under Alternative 3, there is some risk of diminished LWD recruitment in watersheds with large areas owned by small landowners and with high levels of past harvest.

For all three stream types, no harvest can occur within the RMZ except for specific cases which are described above under the west side. As a result, most if not all of the recruitment potential based on RMZ width (described above) would be maintained unless stand manipulation was deemed necessary to facilitate riparian condition.

Similar to the west side, under both the 100-year SPTH and 250-year SPTH assumptions the EBAI suggests Alternative 3 has the greatest recruitment potential along all streams compared to Alternatives 1 and 2 (Figure 3.4-10 and 3.4-12). The major differences in the two SPTH assumptions occur along steeper (greater than 20 percent) slopes that generally (but not always) are nonfish-bearing streams. Of particular note is that the EBAI for all streams is just short of complete protection under the 100-year SPTH assumption, and is just short of complete protection for fish-bearing streams under the 250-year SPTH assumption. These results are primarily due to the fact that, although high gradient stream RMZ width is less than one SPTH, most of the recruitment potential is obtained within 70 feet to the stream. In addition, a large proportion of seasonal streams (defined under Alternative 2), which make up the greatest proportion of stream miles across the landscape fall within the 0 to 20 percent gradient category and therefore, receive a 200-foot, no-harvest RMZ.



Chapter 3

Stream Shade

ALTERNATIVE 1

WEST SIDE

Type 1, 2, and 3 Waters

The RMZ width criteria for full stream shade protection is 0.75 SPTH and trees closer to the stream have a greater ability to provide shade (Figure 3.4-3). On the west side a 0.75 SPTH, which ranges from 68 to 150 feet under a 100-year SPTH assumption and 75 to 185 feet under a 250-year SPTH assumption (depending on site class), is considered to provide full protection for stream shade along Type 1-3 streams. Along most Type 1, 2 and 3 streams the RMZ widths do not meet this requirement under Alternative 1. The few exceptions are primarily where maximum RMZs are applied to low site classes. Also, wider buffers and additional riparian leave trees are sometimes required to meet the shade rule, particularly in lower elevation areas.

In addition to RMZ widths that do not meet full protection criteria, shade levels can be further reduced along Type 1 through 3 streams because the FPRs allow substantial canopy removal through selective harvest within the RMZ. In general, the studies reviewed by Belt et al. (1992) indicated that removal of forest canopy within the buffer strip reduces its effectiveness by reducing shade. As a result, the level of protection is too low to maintain adequate stream shade to provide full protection.

On the west side, Alternative 1 would result in moderate to high risk of diminished shade along Type 1 to 3 streams.

However, under Alternatives 1 and 2, the FPRs include the shade rule which is designed to maintain shade so water temperatures will not exceed water quality standards. As guidance for meeting the requirements of the shade rule, the Forest Practices Board Manual includes a shade screening tool and, if necessary, water temperature modeling to determine the likely effects of removing riparian shade trees. The shade rule requires maintenance of specific shade levels depending upon the stream water quality type (A, AA, etc.) and elevation. The screening tool uses overhead canopy closure (measured mid-stream using a spherical densiometer) as an index for actual shade. Depending on elevation (particularly lower elevations) there is increased shade requirements along Type 1-3 streams due to the implementation of the shade rule. As a result, the width of the RMZ and leave tree requirements within the RMZ may increase to the maximum and shade levels are likely to increase. In tests of the shade screening tool, Rashin and Graber (1992) found that the screening tool was effective at 78 percent of the 9 sites examined (excluding those with flow loss within the reach). Consequently, there is some risk that streams could be miscategorized using the screening tool and provided inadequate minimum shade requirements. The results from Rashin and Graber (1992) also suggested that prior to implementation of the water temperature screening tool and model, low elevation streams, under 1,640 feet, were at higher risk of exceeding water quality standards than higher elevation streams. It is not known to what degree the screening tool and model has been more effective at identifying these low elevation, at-risk streams and providing more effective shade retention.

Currently, the majority of trees in the RMZs are in early seral stages (see Table 3.4-3). Therefore, depending on stream size much of the lands may not be effective at providing



shade under existing conditions and it may take many years of growth before riparian trees will be able to provide adequate shade. However, because there is no limitation on entry into the RMZs, it is likely that many stands would be harvested again during the next rotation, prior to or near the time that riparian trees are approaching more complete shade function.

On the west side, Alternative 1 would result in very high risk of diminished shade along Type 4 and 5 streams.

Type 4 and 5 Waters

RMZs are not required for Type 4 waters except under limited site-specific conditions and would not exceed 25 feet in any case. Therefore, RMZs for Type 4 streams do not meet the minimum widths required to maintain adequate shade.

Type 4 streams are most susceptible to alteration in shade since there are no RMZ or leave tree requirements. There is some limited reduction in risk due to the fact that smaller streams can be partially or fully shaded with overhanging shrubs, young trees, and slash (timber harvest debris) which are not large enough to shade larger streams.

EAST SIDE

Type 1, 2, and 3 Waters

A 0.75 SPTH, which ranges from 45 to 98 feet under the 100-year SPTH assumption and 64 to 147 feet under the 250-year SPTH assumption, depending on site class, is assumed to provide full protection for shade on the east side (Spence et al., 1996; FEMAT, 1993). Most RMZ buffer widths along Type 1, 2 and 3 streams do not meet this requirement, since the minimum RMZ width is 30 feet, which is less than 0.75 SPTH for all site classes. The few exceptions where the 0.75 SPTH would be met are primarily where maximum RMZs are applied to low site classes.

On the east side, Alternative 1 would result in moderate to high risk of diminished shade along Type 1-3 streams.

Similar to the west side, the possibility of harvest activity within the RMZ under Alternative 1 for all stream types leaves the possibility that shade will be further reduced. However, the shade rule would also be implemented on the east side and RMZ width and leave tree requirements could be increased to the maximum for maintenance of shade levels. The magnitude of temperature increases resulting from canopy removal on the east side might be expected to be slightly less than for the west side because the degree of shading provided by more open forest types (e.g., ponderosa pine) is lower than for coastal and western Cascade streams. However, many streams east of the Cascades approach the maximum thermal tolerance level for salmonids during the summer and these smaller increases in temperature might be equally or more detrimental to salmonids.

Similar to the west side, the majority of the riparian vegetation is currently in early seral stage and most of the remainder is in mid-seral stage (see Table 3.4-3). The younger stands are not expected to provide shade that approaches adequate function in the short-term. Similar to the west side, the riparian stands would likely be harvested again prior to approaching adequate shade along all streams. However, because the rotation is longer on the east side a greater proportion of the landscape would likely be functioning prior to the next rotation.



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On the east side, Alternative 1 would result in very high risk of diminished shade along Type 4 and 5 streams.

Type 4 and 5 Waters

RMZs are not required for Type 4 streams, except for limited site-specific conditions and, in any case would not exceed 25 feet. Therefore, RMZs for Type 4 streams are less than the minimum buffer width required for adequate protection of shade.

The greatest risk is for Type 4 streams that have no leave tree requirement and consequently no protection for shade. However, for many Type 4 streams, the risk is reduced because they are effectively shaded by overhanging shrubs, young trees, and slash. In addition, selective harvest is the main silvicultural strategy (approximately 70 percent of the landbase) applied to the east side (Pers. Com., Debbie Robinson, DNR, January 5, 2000). Therefore, some protection may be provided even if no RMZ is applied. Overall, however, the lack of RMZ buffers on Type 4 streams would not meet the level recommended for minimum protection, at least in the short- and mid-term.

ALTERNATIVE 2

WEST SIDE

Type S and F Streams

Under Alternative 2, the RMZ widths under the 100-year SPTH and 250-year assumptions nominally exceed the width recommended in the literature to provide complete shade for all Type S and F streams if considering only the width of the RMZ and not the RMZ prescriptions. However, a substantial portion of the available trees can be harvested within the inner and outer zones. Consequently some level of shade reduction can be expected under Alternative 2. Nevertheless, the cumulative percent curve for shade (Figure 3.4-3) shows that the relationship between buffer width and potential shade from the adjacent riparian zone is non-linear with a greater percentage of shade occurring closer to the stream. For example, approximately 75 percent of shade effectiveness is within 0.5 SPTH. In addition, RMZ widths begin at the edge of the CMZ where they are present which provides additional protection to vegetation in close proximity to a stream.

The no-harvest zones adjacent to the stream bankfull width or CMZ range from 50 feet under Option 1 (thinning from below) to 80-100 feet under Option 2 (leave trees closest to the water). A 50-foot no-harvest buffer is expected to provide 53 to 91 percent of full shade protection under the 100-year SPTH assumption and 44 to 86 percent of full shade under the 250-year SPTH assumption, depending upon site class. Under Option 2, an 80-foot no-harvest zone would provide 75 to 100 percent of full shade protection under the 100-year SPTH and 64 to 100 percent under the 250-year SPTH assumption. A 100-foot no harvest zone would provide 86 to 100 percent (100-year SPTH) or 76 to 100 percent (250-year SPTH) of full shade protection. The core zone would maintain the maximum available overstory canopy within the immediate area adjacent to the stream.

Under Option 1, in addition to the core zone adjacent to the stream bankfull width or CMZ, the inner zone extends out to 0.66 of the 100-year SPTH for streams less than or equal to 10 feet wide and to 0.75 of the 100-year SPTH for streams greater than 10 feet wide. These widths equate to 0.54 SPTH or 0.61 of the 250-year SPTH assumption for small and large streams with site classes I - IV, respectively. The core plus inner zone widths exceed 100 feet for site class I and II soils and site class III soils for streams greater than 10 feet



On the west side, Alternative 2 would result in low to moderate risk of diminished shade along Type S and F streams.

wide. However, there are no data in the literature that demonstrates the level of shade protection that is available from the combination of a no-harvest zone and a selective harvest zone. The selective harvest that occurs within the inner zone of Option 1 leaves the largest, and therefore the tallest, trees which have the highest likelihood to provide shade. The taller trees in the inner zone are also those that have the highest likelihood of providing additional shade to the stream. It is possible that under some circumstances leave trees in the outer zone may also provide some shade, but this will likely be minimal or none in most cases.

Similar to Alternative 1, under Alternative 2 the shade rule must also be taken into consideration, which would increase shade in areas where site-specific conditions warrant it. However, the shade rule is slightly different compared to Alternative 1. Under Alternative 1 the shade rule applies to trees up to the maximum RMZ width for that stream type and width. Under Alternative 2, the shade rule applies to all trees within 75 feet of the stream channel or CMZ, if present. In addition, canopy closure measurements are made at the edge of the CMZ when it is present or mid-stream otherwise. Nevertheless, it is unclear to what extent the shade rule would actually contribute additional protection when implemented because most shade producing trees that would be protected by the shade rule would already be protected by the no-harvest core zone, the thin from below requirements under Option 1, and the no-harvest portions of the inner zone under Option 2. Similar to all alternatives reductions in shade would occur from yarding corridors and roads located in the RMZ.

All factors considered, the overall RMZ effectiveness for providing shade protection to Type S and F streams within this alternative is considered moderate to high based upon the FEMAT (1993) shade curve, but high under most situations. Consequently, the level of risk for diminished shade is considered low to moderate. No-harvest buffers 100 feet wide have been suggested to have similar levels of shade protection as old-growth forests in western Oregon and Washington (Murphy, 1995; Johnson and Ryba, 1992) and this width would be available under many Option 2 situations. In addition if the channel shifts within the CMZ in the future, the stream would still be provided shade.

The large proportion of RMZs that are in early-seral stages are not expected to be producing complete shade capacity within the short-term (see Table 3.4-2) and some of these stands are under-stocked by conifers and dominated by hardwoods. Mid-seral stands would regrow to the point that canopy closure would be sufficient to produce shade comparable to a later seral stand near the end of a 50-year period (see Table 3.4-3), however core zones that are re-growing as understocked hardwood-dominated stands may not return to their full shading potential (Sullivan, K.; personal communication; February 28, 2001). Consequently, even no-harvest zones have some risk of not supplying long-term shade needs.

On the west side, Alternative 2 would result in moderate risk of diminished shade along perennial nonfish-streams and high risk along seasonal non-fish streams.

Type N Streams

For at least 50 percent of the Type N_p stream length, a 50-foot RMZ will be provided, which meets the small stream width criteria. Sensitive sites (which include seeps, springs, initiation points of perennial flow, and others) would also receive protection from forest



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practices with 50-foot buffers. In addition, a 50-foot buffer would be required for the first 500 feet upstream of the confluence with the Type F or S stream. These 50-foot buffers would provide 53 to 91 percent of full shade protection under the 100-year SPTH assumption and 44 to 86 percent of full shade under the 250-year SPTH assumption, depending upon site class. For all other Type N streams, no RMZ is provided and therefore no shade protection is guaranteed, though some shade will be maintained from understory vegetation.

There is moderate to high uncertainty that buffers along Type N_p streams would be effective in maintaining temperature of waters delivered to Type F and S streams.

The greatest risk of shade reduction is along portion N_p streams that have no leave tree requirement, resulting in even-aged timber harvest adjacent to the stream and no shade protection. Similar to the Type 4 waters under Alternative 1, these streams would not receive an adequate shade protection level, at least in the short term which could result in water temperature increases.

However, for Type N_p streams, the risk would be reduced because many N_p streams are effectively shaded by overhanging shrubs and young trees and as discussed above at least 50 percent of these streams are provided a 50 ft no-harvest RMZ. The 50 foot no-harvest buffers along the lower 500 feet of Type N_p streams are intended to allow water temperatures to equilibrate to shaded conditions prior to mixing with, or becoming, a Type F or S stream. There is a moderate to high level of uncertainty that these buffers will be effective. Consequently, this is a priority research topic under the adaptive management program.

In watersheds with high proportions of small landowners, the lack of RMZs on all Type 4 and 5 streams permitted by Alternative 2, would produce increased risk of adverse effects. These effects of Type N streams could also be transferred to downstream fish streams until streams temperatures equilibrated with local environmental conditions.

EAST SIDE

Type S and F Streams

On the east side, Alternative 2 would result in low to moderate risk of diminished shade along Type S and F streams.

Under Alternative 2, the total RMZ widths nominally exceed the widths recommended in the literature for shade along Type S and F streams, but include both no-harvest and partial-cut silvicultural prescriptions. The 30-foot no-harvest core zone adjacent to the bankfull width (or CMZ) would provide 49 to 86 percent of full shade protection under the 100-year SPTH assumption and 35 to 69 percent of full protection under the 250-year SPTH assumption. Inner zone widths are 45 feet for streams less than or equal to 15 feet wide and 70 feet for streams greater than 15 feet wide. If the inner zones were no-harvest zones, 75 feet would provide 93 to 100 percent of full shade under the 100-year SPTH assumption, and 73 to 100 percent under the 250-year SPTH assumption. A 100-foot buffer would provide 100 percent of full shade under the 100-year SPTH assumption and 87 to 100 percent of full shade under the 250-year assumption. However, some reduction in shade would be present because some level of harvest is allowed within the inner zone. Leave tree requirements for inner zones are dependent upon habitat type (ponderosa pine, mixed conifer, or high elevation) and site class. Leave trees include 21 to 50 of the largest, and consequently tallest, trees per acre in the ponderosa pine and mixed conifer habitat

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types. The high elevation habitats follow the “thin from below” prescriptions used in western Washington.

There is a moderate level of uncertainty that leave tree requirements in the inner zone will provide adequate shade protection, particularly if the core zone is not fully stocked. In regions with higher ambient air temperature, any potential risk of shade reduction could increase the risk of adverse affects to stream temperature (see Section 3.6.3.2). However, other prescriptions may reduce the risk associated with this uncertainty, including implementation of the bull trout overlay along Type S and F streams, and the shade rule.

Under the shade rule, areas that are part of the bull trout overlay, an additional 45 feet outside of the core zone (75 feet total) is prescribed to maintain all available shade. This does not necessarily imply no-harvest, but the level of additional protection is highly site specific. As discussed previously for the west side, the shade rule is based upon canopy closure and shade protection under the bull trout overlay is implemented similarly. The shade rule protects existing shade rather than potential future shade. Consequently, some trees are potentially at risk of harvest in the inner zone or within 75 feet of the stream within the bull trout overlay because they do not currently provide shade, but could if they were taller. This limitation of the rule is more important on the east side than the west side because stands tend to be more open. In a fully stocked stand, the trees closest to the stream would provide the bulk of the shade protection with trees further out providing a marginal increase in the level of additional shade. In contrast, trees further from the stream have more potential to provide shade in a more open stand. Compared to the west side, there is a greater likelihood that the shade rule will protect additional shade producing trees on the east side, particularly within the bull trout overlay, because the core zone is narrower and the shade rule is consequently applied to a larger area.

Similar to the west side, any yarding corridors and roads located within the RMZ would also reduce the level of shade protection. All factors considered, Alternative 2 is considered to have a low to moderate risk of diminished shade along Type S and F streams.

For a large proportion of the RMZs that are in early seral stage, effective shading from the RMZ is currently compromised. Most of the early seral stages are maturing and, without any new harvest taking place, the reestablishment of suitable canopy cover over the mid term to provide adequate stream shade would occur over most streams. Therefore, as in the case for any alternative, the implementation of wider RMZs retaining more trees for shade protection, would still require many years for sufficient shade to be produced in most cases.

Type N Streams

Type N_p streams with a 50-foot RMZ meet the shade requirement for smaller streams (<5 ft). For some other Type N_p streams, no RMZ is provided and therefore no overstory shade protection is provided.

The 50-foot no-harvest RMZ along some Type N_p streams would provide complete shade protection. Type N_p streams with 50-foot selective harvest RMZs, have a greater risk of shade reduction. However, for Type N_p streams, the risk is reduced because many Type N_p

On the east side, Alternative 2 would result in moderate risk of diminished shade along perennial nonfish-bearing streams and high risk along seasonal nonfish-bearing streams.



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streams are effectively shaded by overhanging shrubs and young trees. The greatest risk of reduction of shade is along N_p streams that do not have any RMZs, similar to the west side. Therefore, these streams are at the greatest risk of shade loss over the short- and long term until new trees grow to an adequate size.

As is the case for the west side, under Alternative 2 watersheds on the east side with high proportions of small landowners would have higher risk of temperature effects on Type N streams because no RMZs are required and leave tree requirements are reduced relative to the standard rules. Water temperature increases could be transferred to downstream fish streams until temperature equilibrated with local environmental conditions.

ALTERNATIVE 3

Alternative 3 would result in low risk of diminished shade along fish-bearing streams statewide.

Under Alternative 3 for streams 0 to 20 percent gradient, the 200 feet RMZ width would meet or exceed the width recommended in the literature for maintaining shade under both the 100-year and 250-year SPTH assumptions. Streams with 20 to 30 percent gradient would receive a 100-foot no-harvest buffer that would provide 100 percent of full shade protection under the 100-year SPTH assumption and 87 to 100 percent of full protection under the 250-year SPTH assumption. The only exceptions would be along streams that are greater than 30 percent that have a 70-foot no-harvest RMZ. These high gradient streams meet the 0.75 RMZ for west side site class V and east side site class III, IV and V areas. These high-gradient streams tend to be small and would, likely be provided complete shade protection from the RMZ. Overall, the RMZ width provided should be sufficient to maintain most if not complete protection of shade on these streams. The timing for recovery of shade along early- and mid-seral stage RMZs would be similar to Alternative 2.

Alternative 3 would result in low risk of diminished shade along most nonfish-bearing streams statewide, except for some small streams with very high gradients (which would at least receive a high degree of protection).

Overall, for both the east and west sides and for all streams, most if not all shade is protected. In general, the expansive no-harvest RMZs provide a high level of protection, and have a low risk of shade reduction. Alternative 3 provides the highest level of shade protection, when compared to all other alternatives for all streams. In addition, all the RMZ widths are within the range considered to have less likelihood of being susceptible to appreciable mortality from windthrow.

Leaf and Needle Litter Production

ALTERNATIVE 1

WEST SIDE

On the west side, Alternative 1 would result in moderate risk of diminished leaf and needle litter production along Type 1-3 streams.

A 0.5 SPTH, which ranges from 45 to 100 feet depending on site class under the 100-year SPTH assumption and 50 to 124 feet under the 250-year SPTH assumption, is considered to provide full protection for leaf and needle litter inputs based on FEMAT (1993). For current FPRs, depending on site class, full protection is provided based on RMZ buffer widths to Type 1, 2, and 3 streams when implementing the maximum RMZ widths. However, the minimum RMZ width of 25 feet does not meet the 0.5 SPTH required for complete protection of leaf and needle litter (Figures 3.4-7 and 3.4-8). For each stream type, RMZ buffer width can vary between the minimum and maximum values, depending on the extent of wetland vegetation or the width needed for shade. For Type 4 and 5



waters, RMZs are not required except for site-specific conditions and, in this case, would not exceed 25 feet. Therefore, RMZs for Type 4 and 5 streams do not meet the 0.5 SPTH required for complete protection under the maximum protection provided by the current FPRs.

For Alternative 1, leaf and needle litter recruitment would be compromised along Type 1 through 3 streams because the FPRs allow substantial reduction in overstory conifers and hardwood removal through selective harvest within the RMZ reducing the quantity of biomass that would likely be recruited. For streams that do not meet the established criteria of 0.5 SPTH combined with the selective harvest prescriptions, the risk of reducing leaf and needle litter recruitment would increase. There is a compounding of risk when both the required RMZ width is not met and selective harvest is allowed within the limited size RMZ.

On the west side, Alternative 1 would result in very high risk of diminished leaf and needle litter production along Type 4 and 5 streams.

Even greater risk is associated with the Type 4 and 5 streams that have no RMZ or leave-tree requirement, however. The size and morphology of a small low-order stream greatly influences the deposition and processing of organic materials. Litter is primarily deposited into small steep-gradient streams in forested areas high in a watershed. Higher order streams are less likely to retain deposited organic material until it has been decomposed. Therefore, these small (low order) streams are important to the productivity of larger (high order) stream in lower reaches of the watershed because they are a major source of organic material (IMST, 1999). The exact proportion of detrital production that comes from Type 4 and 5 streams is not well documented in the literature; however, it may be an important portion of the overall productivity. The lack of RMZ buffers on Type 4 and 5 streams would not meet the protection recommended for detrital input needs, at least in the short term, and probably only in localized areas while vegetation grows back.

There would likely be an interruption of detrital input until the riparian forest has grown for many years after the Type 4 and 5 streams are harvested. The Type 4 and 5 streams would then produce some leaf and needle litter, although production might not reach full production in the short or long term. In addition, the type of the litter may be different than the pre-harvest stands because of shifts in the ratio of coniferous versus deciduous vegetation. The type of detrital input can affect not only its nutritional value, but also the amount of time needed for decomposition (Gregory et al. 1987). To what extent leaf and needle litter composition is altered is difficult to determine because; 1) timber harvest occurs in localized areas at varying times within a watershed; and 2) all forest seral stages provide some level of leaf and needle input, although in varying quantities.

There is uncertainty as to what order of magnitude leaf and needle litter is altered since timber harvest occurs in localized areas at varying times in a watershed, and all seral stages provide some level of input.

Currently, most riparian vegetation is in an early to mid-seral stage (see Table 3.4-2). Stand age significantly influences detrital input to a stream system. Therefore, these stands will not be producing leaf and needle litter that approach natural background levels in the short term (see Table 3.4-2). Mid-seral stands would re-grow to the point that canopy closure would be sufficient to produce leaf and needle litter comparable to a later seral stand near the end of a 50-year period (see Table 3.4-3). As a result, just as the stand is meeting detrital input production levels, the stand would likely be harvested again for the next rotation, never allowing complete return to natural production levels.



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EAST SIDE

On the east side, Alternative 1 would result in moderate risk of diminished leaf and needle litter production along Type 1-3 streams

A 0.5 SPTH, which ranges from 30 to 65 feet, depending on site class under the 100-year SPTH assumption and 43 to 98 feet under the 250-year SPTH assumption, is considered to provide full protection of leaf and litter inputs on the east side. Under current FPRs in eastern Washington full protection is provided based on RMZ widths to Type 1, 2 and 3 streams when implementing the maximum and average RMZ widths. Site class I, requires a greater RMZ width to maintain the leaf and needle litter zone which is considered complete protection. The minimum RMZ widths of 30 feet meets the target width of a 0.5 a SPTH for site class V areas only under the 100-year SPTH assumption (Figures 3.4-7 and 3.4-8). For Type 4 and 5 waters, RMZs are not required and, therefore, these do not meet the 0.5 SPTH required for complete protection under all circumstances.

On the east side, Alternative 1 would result in very high risk of diminished leaf and needle litter production along Type 4 and 5 streams.

As for the west side, the possibility of harvest activity within the RMZ under Alternative 1 for all stream types leaves the possibility that leaf and needle litter production would be compromised. The greatest risk is for Type 4 and 5 streams that have no leave tree requirement and timber harvest can occur adjacent to the stream. The lack of an RMZ on these smaller streams would indicate that Type 4 and 5 waters receive no protection of leaf and needle litter recruitment. However, uneven-aged (partial-cut) timber harvest strategies are currently applied to approximately 70 percent of the east side forested landbase (personal communication Debbie Robinson, DNR, January 5, 2000). Therefore, some incidental protection is provided even if no RMZ is applied. Overall, the lack of RMZ buffers on Type 4 and 5 streams would not meet the level required for full protection of leaf and needle litter input, at least in the short term, and probably in most areas for the mid and long term.

Currently, most riparian vegetation is in early-seral and mid-seral stages (see Table 3.4-2). These young stands would not be producing leaf and needle litter that approach natural background levels in the short term (see Table 3.4-2). Similar to the west side, most stands would likely be entered again prior to the complete return of detrital production.

ALTERNATIVE 2

WEST SIDE

On the west side, Alternative 2 would result in low risk of diminished leaf and needle litter production along Type S and F streams.

Under Alternative 2 the overall RMZ widths exceed the width recommended in the literature for leaf and needle litter production for Type S and F streams. Type N_p streams with a 50-foot RMZ receive most of the protection required to maintain leaf and needle litter input, but not at the level recommended by the literature for full protection. For some portions of Type N_p and N_s streams, no RMZ would be provided and, therefore, no protection of leaf and needle litter would be provided.

The no-harvest zone ranges from 50 feet under Option 1 to 80 to 100 feet under Option 2 should maintain most of the RMZs leaf and needle litter input capacity along Type S and F streams. In addition, the inner zone, which is a limited selective harvest prescription on Type S and F streams would not appreciably reduce the ability of the RMZ to contribute leaf and needle litter, especially when combined with the core zone no-harvest area. These RMZs would provide continuous inputs for leaf and needle litter to streams and would

On the west side, Alternative 2 would result in moderate risk of diminished



allow the maintenance of stream productivity in the short and long-term depending on the stand age and structure.

The greatest risk of reduction of leaf and needle input is along the Type N_p and N_s streams that have no leave tree requirement resulting in even-aged timber harvest adjacent to the stream. The lack of an RMZ on these smaller streams would indicate that these waters receive no protection of leaf and needle litter recruitment. Similar to the Type 4 and 5 waters under Alternative 1, these streams would not meet the requirements for adequate protection of detrital input, at least in the short term, and probably only in localized areas while vegetation grows back. Similar to Alternative 1, in many areas a shift in the initial type of detrital input can be expected from coniferous needles to deciduous vegetation. However, a large proportion of N_p streams (50 percent or greater depending on the number of sensitive sites) would be provided a 50-foot, no-harvest RMZ, substantially reducing this risk.

Recruitment of leaf and needle litter from nonfish-bearing streams to downstream fish-bearing streams is of concern, especially in watersheds with a high level of past harvest and/or high proportion of ownership by small landowners.

On the east side, Alternative 2 would result in low risk of diminished leaf and needle litter production along Type S and F streams.

On the east side, Alternative 2 would result in moderate risk of diminished leaf and needle litter production along perennial non-fish streams and high risk along seasonal nonfish-bearing streams.

Because of the large proportion of RMZs that are in early- and mid-seral stages, they would not be expected to produce leaf and needle litter that approaches natural background levels in the short term (see Table 3.4-2). Mid-seral stands would grow to the point that canopy closure would be sufficient to produce leaf and needle litter comparable to a later seral stand near the end of a 50-year period (see Table 3.4-3). Because the RMZs would not be re-entered until the desired future condition was met, most stands would have the opportunity to return to natural production levels over the long-term.

EAST SIDE

Under Alternative 2, for all Type S and F streams total RMZ widths exceed the 0.5 SPTH recommended in the literature for leaf and needle litter production. For Type N_p streams that receive a 50-foot RMZ, the 0.5 SPTH is met for site class II through V and protects most of the area for site-class I. Under the partial-cut strategy, all N_p streams are provided with an RMZ, and under the clear-cut strategy, at least 70 percent of the N_p streams are provided with an RMZ. For all other Type N_p and N_s streams, no RMZ would be provided, and, therefore, no protection of leaf and needle litter would be provided.

Along Type S and F streams, the 30-foot core zone, which is no-harvest, combined with the selective harvest inner zone, should maintain most of the RMZs leaf and needle litter input capacity. These RMZs would provide continuous inputs of leaf and needle litter to streams and would allow the maintenance of stream productivity in the short- and long-term depending on the stand age and structure.

As described earlier, landowners must identify either a partial cut and/or clearcut strategy within the 50-foot RMZ along Type N_p waters. When the clearcut strategy is identified along no more than 30 percent of the stream in the harvest unit, no harvest RMZs of equal length on both sides of the stream must also be identified. The 50-foot no-harvest RMZ along some Type N_p streams and the 50-foot selective harvest RMZ along others would provide some if not all of the leaf and needle recruitment capacity. However, the some risk would be present from Type N_p designated for the clearcut strategy and N_s stream reaches that do not have any leave tree requirements. Therefore, these streams are at the greatest



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risk of having detrital inputs interrupted over the short- and long-term until new trees grow back in localized areas. For a large proportion of the RMZs that are in early seral stage, production of leaf and needle litter is currently compromised. As a result, only over time will the increased tree biomass occur to allow for increased litter recruitment to streams.

ALTERNATIVE 3

STATEWIDE

Alternative 3 would result in very low risk of diminished leaf and needle litter production along all streams statewide.

Under Alternative 3, the RMZ width for most streams (0 to 30 percent gradient) would meet or exceed the width recommended in the literature for full leaf and needle litter recruitment potential. In addition, the RMZs are no-harvest, providing complete protection of leaf and needle litter production along these streams. The only exceptions are along streams that are greater than 30 percent. These high gradient streams meet the 0.5 RMZ for the west side of site classes III through V and the east side of all site classes. These streams are provided with a no-harvest RMZ of 70 feet. Though the exact proportion of detrital production that comes from these streams is not well documented in the literature, it may be an important portion of the overall productivity. However, in general the RMZ buffer provided should be sufficient to maintain most the detrital inputs on these streams at or near natural conditions. The timing for recovery of leaf and needle input along early and mid seral stage RMZs would be similar to Alternative 2.

Overall, most if not all leaf and needle litter input would be protected for all streams statewide. Alternative 3 would provide the most protection of leaf and needle input when compared to all other alternatives for all streams.

Microclimate

ALTERNATIVE 1

Alternative 1 would result in moderate risk for some, but high risk for most microclimatic variables, statewide.

Under this alternative, microclimatic gradients, and particularly relative humidity and air temperature, would be negatively affected. Sullivan et al. (1990) studied the effects of current forest practices rules on water and air temperature in riparian areas and found significant increases in air temperature. A nearly one-to-one correlation was found between air temperature and percent shade.

Because the RMZ widths would, at most (maximum of 100 feet on Type 1 and 2 streams on the west side and generally 50 on the east side), be only about two-thirds or less of the 147 feet minimum, and because there would be harvest within the buffer, microclimatic conditions would be negatively affected, relative to natural conditions, on all stream types. Air temperature and humidity would be greatly affected. In addition, on the east side, which naturally has higher ambient air temperatures, the change in microclimate could further increase air temperature. On the west side, where the dominant early seral riparian area is predominantly made up of coniferous forest, there is no long-term goal for returning the condition of the riparian area to a conifer-dominated stand which would maintain a seasonally altered riparian zone.

ALTERNATIVE 2

Alternative 2 would result in a moderate risk for most microclimatic variables along Type S and F streams, statewide.

Although there are some differences between the two options under this alternative that might affect air temperature and overall microclimatic gradients, there is not enough

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resolution in the existing understanding of microclimatic gradients to distinguish the effects of Options 1 and 2. Therefore, they are treated the same.

In contrast to Alternative 1, total buffer widths for site classes I and II approach or exceed the minimum buffer widths for overall microclimate gradient maintenance, at least on fish-bearing streams. However, because some level of harvest is allowed within the RMZs, the natural gradients would not likely be maintained. Within the no-harvest zone of buffers on fish-bearing streams, relative humidity and other parameters would probably be somewhat lower than under natural conditions, since decreased humidity in the adjacent selectively harvested inner and outer zones would affect the core zone to some extent.

The adverse effects to microclimate along nonfish-bearing streams would be greater. For the Type N_p and N_s stream segments that do not receive an RMZ, no protection would be provided. On Type N_p stream segments that receive some protection from no-harvest RMZs, the 50-foot width is at most one-third of the minimum recommended buffer for the various microclimate variables.

Air temperature and humidity would be affected under this alternative, because the buffer width for maintaining these gradients is even greater than for other microclimatic gradients. The eastside air temperature in the RMZ is likely to have a greater change since ambient air temperatures tend to be higher than the west side.

ALTERNATIVE 3

Among the alternatives considered in detail, Alternative 3 provides the highest degree of protection of microclimatic gradients. Streams with instream gradients of less than 20 percent would receive 200-foot, no-cut buffers. This would be sufficient to maintain microclimatic gradients for most variables. Air temperature, humidity, and windspeed would nonetheless be affected to some extent, since they require wider buffers (240 to 787 feet) to maintain natural gradients.

Streams with higher instream gradients would receive somewhat less protection. A stream with an instream gradient between 20 and 30 would receive a 100-foot, no-cut buffer, while streams with higher instream gradients would receive a 70-foot, no-cut buffer, which is high risk for most microclimate variables. Under both situations, natural microclimate gradients would be modified, but the extent of modification would be lower than Alternatives 1 and 2. However, as with lower gradient streams, air temperature, humidity, and wind speed would be significantly affected across riparian areas.

Alternative 3 would result in low risk for modifying most microclimate variables along streams less than 20 percent gradient and moderate to high risk elsewhere.